Energy, Mines and Resources Canada
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CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

MINING RESEARCH LABORATORIES ANNUAL REPORT 1984-1985

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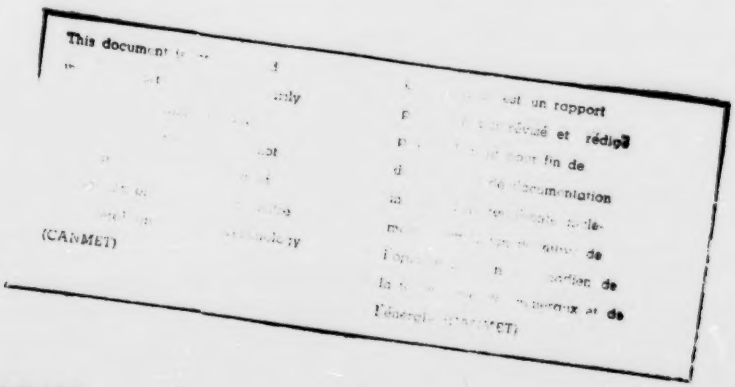
MAY 1985



MINERALS & EARTH SCIENCES PROGRAM
MINING RESEARCH LABORATORIES
DIVISION REPORT MESP/MRL 85-66(TR)

MICROMEDIA

FOREWORD/AVANT-PROPOS

This Annual Report is an account of the accomplishments of the staff of the Mining Research Laboratories during the 1984-1985 fiscal year. It is the most complete record of the efforts that were made in that period, and is therefore a valuable document for both review and archival purposes. It is distributed to key personnel within CANMET, and to others on a selective basis.

The report has been prepared through the combined efforts of several MRL staff members. Project leaders have contributed summaries of the research projects for which they were responsible. The administrative staff have provided tabulations of: the publications during the year; the contracts and research agreements in effect; participation of staff on technical committees; and staff and staff changes. The production of the report is coordinated by Carol Sabourin.

As always, one of the principal challenges during the year was the maintenance of a steady course towards long-range objectives while still being responsive to urgent requests for assistance. In the 1984-1985 year, because of the rockbursts in Ontario mines, the number of such requests was particularly high. MRL staff attended many meetings of technical committees of inquiry and made submissions to Provincial Inquiry into Ground Control and Emergency Preparedness in Ontario Mines (Stevenson Commission).

Additional demands on staff resources resulted from the initiation of projects in Manitoba, through the Federal/Provincial Mineral Development Agreement, and the need to make detailed evaluations of increasing numbers of unsolicited proposals for research projects from outside organizations.

Ce Rapport annuel est un compte rendu des projets réalisés par le personnel des Laboratoires de recherche minière au cours de l'année financière 1984-1985. Le rapport est un relevé complet des efforts déployés durant cette période ainsi qu'un document de consultation et de référence qui est distribué au personnel clé au sein de CANMET et à d'autres personnes choisies au préalable.

Le rapport a été préparé grâce à la collaboration de plusieurs membres du personnel de LRM. Les chefs de projets ont collaboré en soumettant les résumés des projets de recherche dont ils étaient chargés. Le personnel de l'administration a fourni les listes des publications annuelles, des contrats et des ententes en cours portant sur la recherche, des participants aux comités techniques, du personnel et des changements au sein de celui-ci. Carol Sabourin a coordonné l'élaboration de ce rapport.

Un des principaux défis au cours de l'année a été la poursuite continue des objectifs à long terme tout en répondant aux demandes urgentes de soutien. Ces dernières ont été particulièrement nombreuses au cours de l'année 1984-1985, en raison des coups de toit dans les mines de l'Ontario. Le personnel de LRM a participé à plusieurs comités techniques d'enquête et a fait des coumissions à la commission d'enquête provinciale (Stevenson Commission) sur le "Ground Control and Emergency Preparedness in Ontario Mines".

Les demandes additionnelles sur les ressources en personnel ont découlé du début des projets élaborés au Manitoba dans le cadre des Ententes fédérales-provinciales sur le développement minéral et de la nécessité d'effectuer des évaluations détaillées des offres non sollicitées de projets de recherche, au nombre sans cesse croissant, de la part d'organisations de l'extérieur.

John E. Udd
Director/Directeur
Mining Research Laboratories/
Laboratoires de recherche minière

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INTRODUCTION

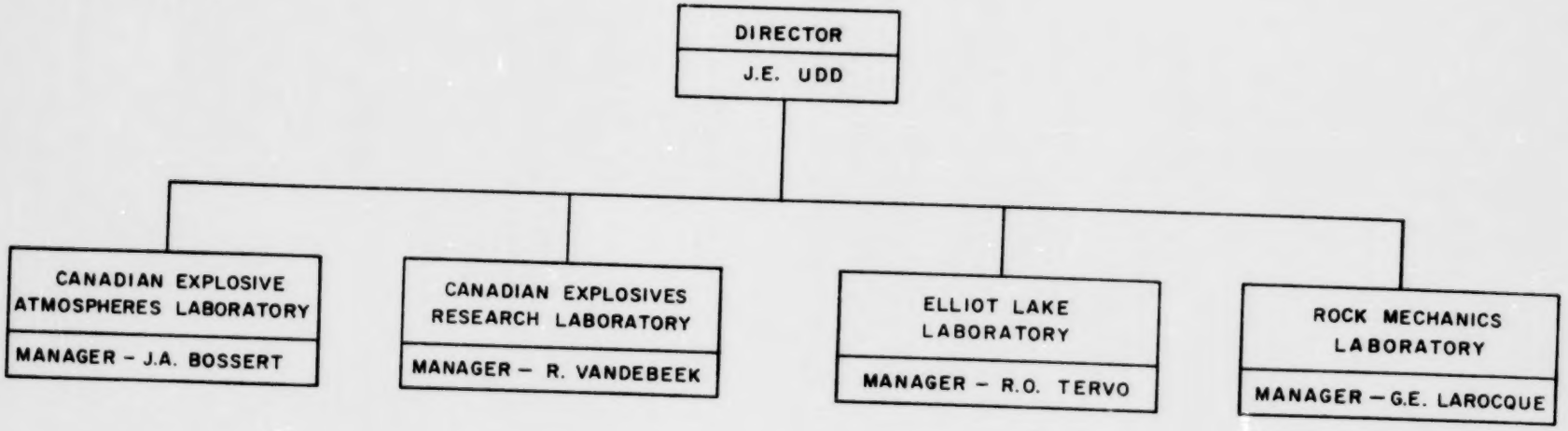
The Mining Research Laboratories are comprised of four units. These are: The Canadian Explosive Atmospheres Laboratory (CEAL), the Canadian Explosives Research Laboratory (CERL), the Elliot Lake Laboratory (ELL), and the Rock Mechanics Laboratory (RML). With the exception of the Elliot Lake Laboratory, all facilities are located at the Bells Corners Complex, near Ottawa.

Research which is undertaken may be broadly classified as being in the areas of Policy, Protection, or Production. Policy research is that which is in support of particular Departmental policy objectives. An example is the maintenance of up-to-date reserves of uranium; which is an on-going project of the Uranium Reserve Appraisal Group (URAG), in the Rock Mechanics Laboratory.

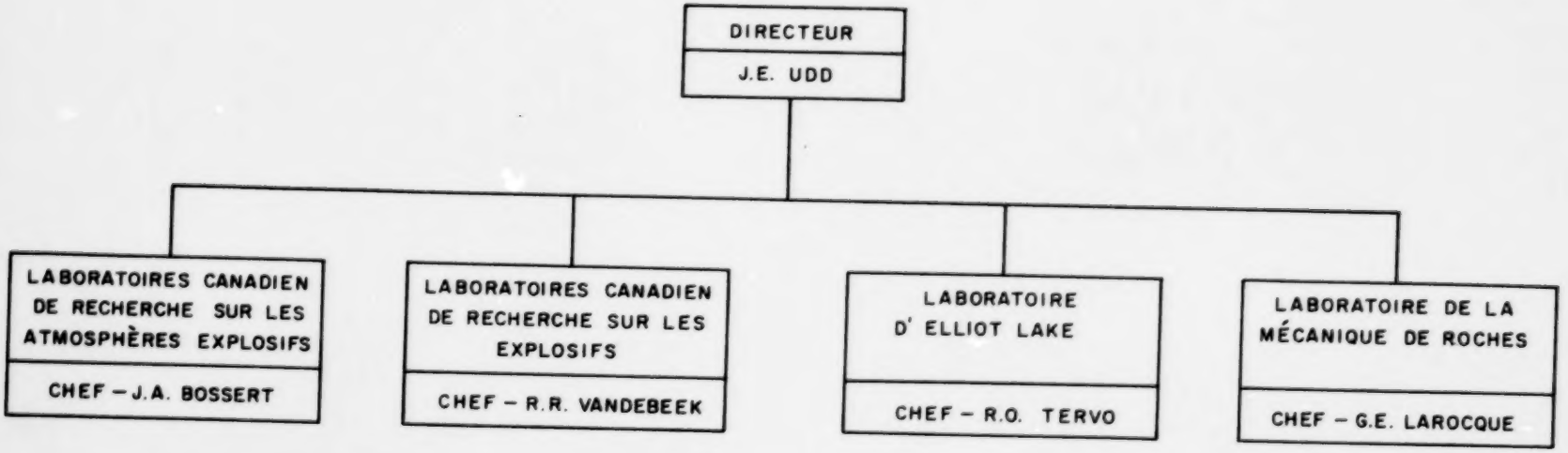
Protection research is that which is in support of health and safety objectives. Examples are the dust research at ELL, and the certification functions of CEAL. Production research is that which is aimed towards improving the productivity of Canadian industry. Much of the work of both the Elliot Lake Laboratory and the Rock Mechanics Laboratory fall into this category.

Projects were funded through the Minerals Technology, Energy Technology, and Administration of the Canada Explosives Act Activities. Most of the work of CERL is funded through Explosives-related activities. Most of the work of CEAL has been funded through the Energy Technology activity. The work of the Elliot Lake and Rock Mechanics Laboratories, on the other hand, has been funded through both the Minerals and Energy Technology Activities.

MINING RESEARCH LABORATORIES



LABORATOIRES DE RECHERCHE MINIÈRE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LABORATOIRE DE LA MÉCANIQUE DE ROCHES
CHEF – G.E. LAROCQUE

PART I

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

SUB-SUB ACTIVITY: EXPLOSIVES TECHNOLOGY

RESOURCES

Person-years:	14
Capital:	$33 k
Operating:	$53 k
Contracts:	$70 k

PROJECTS & OUTPUTS

1. Certification and Technical Advice

Project Leader: E. Contestabile

Objectives

1. To confirm the safety characteristics of all explosives submitted for authorization under the Canada Explosives Act;
2. To provide technical advice on the manufacture, storage and transportation of explosives; and
3. To investigate accidents.

Background

The Certification and Technical advice project of the explosives technology sub-activity has been developed to fulfill the requirement for a "chemist" specified in Section 14 of the Canada Explosives Act. During the 65 years in which the Act has been in force, the laboratory functions of certifying explosives, advising on technical problems of explosives handling and investigating accidents involving explosives have continuously been developed. The expertise in Explosives Safety Engineering is developed in-house through contact with manufacturers' research laboratories, contracted research projects, in-house development projects and international contacts. Because of the proprietary nature of commercial formulations, results of individual examinations for authorization are, and remain, confidential.

Responsibilities under the project continue to increase because of technical advances in formulation, added international responsibilities as a major explosives producing country and increasingly critical reactions from the Canadian public to accidental explosions.

Achievements

During the year, 347 new explosives were examined for authorization. These involved some 2544 sample units of work. Corresponding figures for the year 1983/84 were 184 and 2013, respectively, and for 1982/83 were 159 and 1838. Details of the samples by Classes are to be found in the "Summary of Samples Examined" section of this report.

Although there was almost a doubling in the total number of samples examined compared to the previous year, the estimated sample units increased by only 25%. The sample unit concept is used to account for differences in effort required for different sample types. For 1984/85, there was a significant increase in Fireworks, Class 7.2.1, which require proportionately less effort for evaluation than other Classes of explosives.

There were no major accidents in manufacturing during the past year which required the laboratory's involvement. Assistance was given to industry in identifying the cause of powder ignitions occurring during the manufacture of Nonel shock tubing [ACEA/MRL 85-46(CF)]. The laboratory spent considerable effort in assisting Canadian Arsenals in trying to identify the cause of ignitions in delay elements which resulted in the destruction of a magazine.

In cooperation with CIL Inc. a presentation for the United Nations Group of Experts on Explosives to obtain approval for a new packaging for TNT was prepared. Similarly, a submission based on CERL observed trials was made to the Group of Experts on Explosives to obtain a new entry for rocket motor igniters. The dust explosion potential of Amatol dust was also investigated. To provide guidance to the Chief Inspector of Explosives and to industry, a series of tests on propellants was planned and executed. A number of trials on green propellant (solvent wetted propellant) were observed and based upon the results, further trials on ignitability are planned. Work was also completed on wall panels for use in security installations and a report was issued [ACEA/MRL 84-50(CF)]. Guidance was given to a pyrotechnics manufacturer on the requirements for an in-house hazard evaluation facility.

2. Explosives Research and Development

Project Leader: K.K. Feng

Objectives

To advance technology related to the manufacture, storage, transportation and use of explosives, specifically:

1. By 1985, to characterize the safety properties of the new emulsion explosives; and
2. By 1986 to verify the proposed United Nations classification procedures for incorporation into the Canada Explosives Act and Regulations, and to establish capabilities for testing explosives to these U.N. procedures.

Background

Canada is working with other countries under the auspices of the United Nations to develop a unified, international classification system for dangerous goods, including explosives. Current planning is for the Canada Explosives Act to be amended to adopt the proposed new standards by 1987. CANMET is evaluating the proposed new standards, which are based on a hazard-assessment system, together with test procedures used in other countries against the current Canadian standards, which are based on a chemical classification system, and CANMET test procedures to ensure that no significant changes in explosive classification would result. CANMET is acting in a lead agency role together with parallel agencies in other countries in this international evaluation of the proposed new standards. This work is planned to be completed by 1986.

New emulsion explosives are being developed by Canadian industry. These explosives must be characterized, health and safety hazards identified and quantified, and reliable test procedures for routine evaluation developed. This is part of an ongoing effort to upgrade explosives test and evaluation procedures.

Due to the cost and complexity of testing bulk samples of explosives for safety characteristics, CANMET has concentrated for several years on the development of computerized modelling capability to evaluate such parameters as detonation sensitivity, fume generation and propagation properties, based on chemical constituents of explosives. This modelling work has reached the stage where field verification using large samples is necessary. This work will be phased in over the next five-year period.

Achievements

During 1984/85, CERL continued to study the thermal stability of explosives using its accelerating rate calorimeter (ARC). Work was completed on HMX and HMX with RDX as an impurity.

An investigation using the ARC into the thermal properties of an EGMN liquor was also completed. To obtain a better understanding of the ARC's ability to determine decomposition mechanisms of explosives, a detailed study of tetryl was undertaken. Under contract, a study on the interpretation and modelling of thermodynamic data from ARC was completed.

Work was completed on the characterization of emulsion explosives with a report due shortly. Briefly, emulsion explosives are less sensitive to thermal and mechanical stimuli than most slurry explosives. Emulsion explosives detonate at a velocity close to that predicted theoretically and are significantly less sensitive to projectile impact and have reduced propagation sensitivity compared to slurry explosives.

A contract was completed on the propagation sensitivity of commercial explosives in 25-20 mm diameter boreholes. Very large air gaps were found, even with sand as a stemming. It is anticipated that additional work in 15 cm holes will be completed during 1985/86.

Work continued on verification of U.N. classification procedures. The laboratory has the capability, and is acquiring the necessary experience, to perform at least one test in each of the first five Test Series. The laboratory does not have the quantity/distance requirements to do the Test Series 6. To date, however, manufacturer's facilities and military installations have been used. No difficulties have been encountered in using the U.N. procedures to classify explosives. Installation is proceeding of a new fume testing facility. The gas analysis system is complete, the fume chamber is 50% installed, and details for containment of the explosive charge are 75% completed. It is anticipated that trials with the completed assembly will start in late fall. The laboratory's ammunition testing facility has almost been completed after some delays. The pressure barrels and associated instrumentation are currently being evaluated. Work on the impact pressure gauge is essentially complete. CERL cooperated with CIL Inc. in evaluating an NO_x detector for determining positive results in mechanical sensitivity testing of explosives. It was found that this method is extremely sensitive and gives reliable results.

Two multi-year contracts on modelling of explosives phenomena were awarded during the year. The first is to develop a theoretical model to predict the low velocity impact sensitivity of bubble-sensitized slurry explosives. This contract extends to March 1987. The second contract is an experimental verification of a high-velocity impact model for slurry explosives. This model was originally developed in-house and under contract. This contract extends to March 1986. Both contracts are on schedule.

SUMMARY OF SAMPLES EXAMINED AT CERL
Calendar Year 1984

	No. of samples	Estimated sample units
High explosives - Classes 1, 2 & 3	74	1480
Ammunition - Class 6.1	49	392
- Classes 6.2 & 6.3	5	40
Pyrotechnic mixes - Class 7.1	11	220
Fireworks - Class 7.2.1	182	182
- Classes 7.2.2 to 7.2.5	21	210
Miscellaneous	21	210

PART II

MINERAL TECHNOLOGY

SUB-SUB ACTIVITY: MINING METHODS & EQUIPMENT

RESOURCES

Person-years:	4
Capital:	$10 k
Operating:	$10 k
Contracts:	$251 k

PROJECTS & OUTPUTS

1. Equipment Development Technology

Project Leader: L.B. Geller

Objective

To promote the development and application of new mine technology in Canada, and to regularly report on mine technology developments and mine productivity.

Background

The mechanics and economics of excavation technology, especially in hard-rock formations, is of great theoretical and practical importance to the Canadian mining industry. Problems of specific interest to the diamond-drilling industry have been identified as requiring concerted R & D efforts because, while diamond drilling for exploration on surface and underground is vital to the minerals industry, developments in diamond-drilling have fallen behind progress in other mining equipment areas. In particular, there are demonstrated problems in suppressing excessive on-site noise so as to meet new regulatory health standards.

A second mining equipment area identified as requiring R & D emphasis is that of transporting coarse mine products over short distances from mine face to processing plant, specifically through the use of hydrotransport slurry pipelines. Pipelining of fine slurries over long distances has been successfully practised for a number of years; however, transporting coarse slurries over even the relatively short distances in mining operations has not been developed. The specific areas of interest include situations such as the transport of mineral slurries from underground to railhead, from ports to power stations, backfilling of mined-out areas, and the like. The work on slurry pipelines forms a basic component of CANMET's role as Canadian Government representative on international cooperative slurry working groups.

The third area of special interest is that of wire-rope and hoisting technology. Research and development work in this area is being undertaken on a tripartite cooperative basis, involving the Unites States Bureau of Mines, the Ministry of Labour of Ontario, and CANMET.

Achievements

As a result of several meetings with the Technical Committee of the Canadian Diamond Drilling Association, it was decided to temporarily shelve work on all of the other project requests and to concentrate, initially, on all joint efforts on solving the problem of excessive noise levels at the drilling sites. Benchmark dB readings were, therefore, taken of pneumatic underground diamond drills when operating without load in the factory. In-depth consultations were then held as to the best strategies to follow, and estimates were made of the approximate costs involved, both to CANMET and to the industry. As a result, it was decided to submit a request for PILP funding before proceeding further.

An investigation of the problems involved in establishing appropriate formulae for calculating torque and threaded system strengths showed that these could not be achieved by staff of the Mining Research Laboratories alone. Cooperative projects with other government laboratories, and/or with outside agencies would be required (e.g., with university labs, or consultants). Industry being unable to share the costs anticipated, this phase was set aside for the time being.

Coarse-slurry pipelining has been studied on a contractual basis in a 250 mm pipeline for both -10 mm coal and -6 mm silica sand. In addition, extensive discussions were undertaken with scientists from the Federal Republic of Germany (FRG), within the Canada/FRG bilateral agreement on Scientific and Technical Cooperation, to develop a joint project in this area of common interest. A joint research project was agreed to as described in detail in MRL Division Report 84-70. It recommends that work in the FRG cover coarser coal and sand slurries than the sizes that can be tested in Canada. The FRG test pipeline (150 mm diam) is also to be different from the Canadian one.

Work in the cooperative wire-rope and hoisting project covered several joint meetings, both in Canada and in the United States. The tasks, respective responsibilities and tentative schedules for the joint project were agreed to. These include: the study of steel guide arrestment devices; plastic impregnated and created ropes; and brake shoes and non-destructive testing of steel wire-hoist ropes.

2. Interaction of Equipment and Mine Design

Project Leader: J. Pathak

Objectives

1. To review and promote potential mining equipment developments,including those for mine development, production and transportation, and to assess the import of such equipment and associated automation, remote control or robotics, on mine design and mining operations; and

2. To conduct state-of-the-art reviews on mine operational problems, including computer mine design and operations research.

Background

Increasing improvements in safety and productivity often stem from improvements in mining equipment. Examples are load-haul-dump machines replacing separate loading and hauling equipment, and large hole drilling machines reducing the need for sub-levels for drilling. Mine designs have had to evolve to accommodate these developments to best advantage. Future equipment developments in portable crushers, conveyors, turning machines, pre-concentrators, etc., will probably also radically affect mine design.

Successful application of microprocessors, sensors, data transmission, monitoring and control has revolutionized the manufacturing and processing industry. It gives reasons, and there exists considerable potential for transfer of this technology to underground mining and mining equipment.

Achievements

A report on mine equipment development and its relationship to mine design could not be produced because the contractor became insolvent. It took considerable time to recover the files from the receivers. At present, a contract for continuation of the project has been awarded to Brampton Mining Ltd. A report is due in mid-1985.

Prototype development and testing of a remote-controlled mine-sealer has been successfully completed. A draft report has been received, and a final report is under preparation.

Because an inapplicability of conventional mining techniques to the exploitation of deep-seated high-grade uranium deposits, a project was initiated in which possible new techniques and remote-conrolled equipment for special situations would be eliminated.

A report was completed on the computer design of large blasthole stopes. As this project was based on theoretical considerations and computer simulation, it is the intention of CANMET/MRL to test the program in the field, and to make the improvements and/or modifications required in order to create a user-acceptable program for an IBM PC.

3. Canadian Mining Technology Coordination

Project Leader: J. Pathak

Objective

To develop and maintain a national information bank on current and developing mining technology in the Canadian mining industry and other related organizations. The data is to be available for both government and members of the industry, and associated organizations, on a continuing basis. The ultimate objective is to promote cooperation and improve efficiency.

Background

There are many fundamental mining technology improvements being developed on a continuing basis within operating mines, universities, government and other R & D organizations. Sometimes these developments, specifically intended for one particular organization and potentially beneficial to others, are never published. There appears to be a limited interchange of projects which are in progress and results that may be available. An on-going communications network assembling and disseminating such information would be a valuable contribution to mining technology development in Canada.

Achievements

To gather information on R & D, either planned or in progress in various operating mines, universities and other organizations, visits and personal interviews, continued this year. Four reports have been produced and distributed. These are the following:

i) Progress report on mining technology development index. (84-114)

ii) Progress report on Canadian mining technology coordination project. (84-18)

iii) Preview of CANMET's mining technology development index. (85-3)

iv) Towards determining the extent of mining research in Canada. (85-17)

The latter was presented at the 1985 Annual General Meeting of the Canadian Institute of Mining and Metallurgy, in Vancouver, in April.

4. Potash Mining

Project Leader: G. Herget

Objectives

With a view towards increasing current potash recovery, to carry out contract research with regard to Canadian potash mining in the areas of: ground control, environment, and productivity.

Background

Current recovery of potash in Canada is 40% and, though profitable, this represents a significant waste of resources as well as increased costs in underground transportation. A major reason for low recovery is a lack of knowledge of ground stability and methods for backfilling with waste salt.

A review of present potash mining technology and ground control constraints in potash mines was carried out, and eight contracts for studies were completed. These were in the areas of: regional mine stability; world review of mining options for potash; the development of 2-dimensional finite element models for excavations in potash; testing of waste salt as mine backfill; assistance to establish a creep testing facility in Saskatoon; assessment of underground dust levels at work heatings; and two projects to evaluate excavation performances in the field.

Achievements

The two-years of research effort thus far have established new data in many areas:

a) A field program established stress and strain distributions in abutment strata and across yielding pillars. Absolute convergence measurements indicated, for the first time, that floor heave accounts for 73% of total convergence.

b) A new 2-dimensional finite element method, with pre- and post-processing, was developed in order to model underground excavations in evaporites having different failure and creep behaviour.

c) Retreat longwall or shortwall mining might offer better alternatives to the present room-and-pillar mining system.

d) Regional mine stability studies indicated that some of the most pressing problems are: the prediction of potential water inflows into underground mine workings; and the potential corrosion of potash shaft linings, for which no acceptable instrumentation exists at the present.

e) One of the ten creep cells at the Saskatchewan Research Council which had not been evaluated previously, was found to be a very suitable tool for determining the creep parameters for evaporite strata.

f) A survey of available dust monitoring instrumentation identified procedures for measuring dust concentration in potash mine operations.

A more coordinated view of research needs exists now in the potash mining industry. Further leadership by CANMET is needed in order to address industry-wide concerns on water inflow, shaft lining corrosion, and numerical modelling of the behaviour of evaporite strata. Every potash mining company in Saskatchewan sent a representative to the debriefing session which was held in Saskatoon in November 1984.

SUB-SUB ACTIVITY: ROCK MECHANICS

RESOURCES

Person-years:	12
Capital:	$30 k
Operating:	$52 k
Contracts:	$226 k

PROJECTS & OUTPUTS

1. Model Development

Project Leader: Y.S. Yu

Objectives

1. To develop new computer models for evaluating stabilities of underground openings and related structures;

2. To upgrade and enhance software packages and hardware capabilities for mining and geotechnical applications; and

3. To conduct studies related to mining applications, and to develop guidelines for designing underground openings.

Specific contributions of the project to long-term objectives are indicated by some of the milestones below.

Background

Numerical models based on the principles of modern rock mechanics provides the means for predicting the mechanical behaviour of both underground and open pit mines. The prediction and evaluation of ground behaviour is becoming progressively more important in mine design and planning. The ability to determine stresses and displacements induced in the rock mass as a result of mining enables the mining engineer to evaluate and to interpret ground behaviour in a more scientific and rational manner. Special studies to develop guidelines for designing underground openings are also planned.

In addition, in research being developed through the Canada/Manitoba Mineral Development Agreement (MDA) programs are being developed to stimulate R & D for ground control, mine safety and mining technology, to strengthen and diversify the minerals resources base of the provincial economy, and to improve socio-economic conditions of Manitoba.

In northern Manitoba, the cut-and-fill mining method is extensively applied. This method, when used in poor ground conditions, is prone to serious safety hazards and production loss problems. Often, miners may be required to work in very weakened ground. Because extensive scaling, heavy supports, blasting control, and skilled labour are required, alternative mining methods - VBM, or improvements to procedures, will be examined in order to reduce safety hazards and to increase productivity.

To properly control the ground, a better understanding of ground behaviour and its response to mining and the causes of instability is considered essential. Studies in the area of rock mass behaviour, mine stability, sophisticated geomechanical and numerical modelling, and improved mining technology are therefore required.

In underground mines, there is also a need for more effective communications systems. Current systems of warning of fire hazards, in which stench gas is injected in mine air, are inadequate for working areas which receive limited ventilation. A reliable communications system which permits underground personnel to maintain communications almost anywhere within a mine, and with the surface, will be installed and evaluated.

Achievements

In the area of computer applications, most of the software packages (SAP2D, SAP2DC, MSHGEN, SAPPLT, MRLPT, DRUKPRA, DRUKGEN, DRUKPLT, BITEMJ, BEPP) have been converted to ASCI 77 standard for running on the VAX-11/750 system.

A preliminary assessment of a 3-dimensional general-purpose finite element computer code was completed. This indicates that the computer code is sound and useful for mining applications. It has good features on both pre- and post-processors, and, therefore it is planned to convert this software package to run on the MRL VAX mini-computer.

In addition, MRL's VAX system has been brought up to VMS 3.6 level and has been expanded to 3MB memory. An additional DMS-32 board has been installed. This provides additional 16 channels to MRL staff. A magnetic tape sub-system has been installed. User's system backup procedures have been developed. A laser printer with the typesetting language has been implemented on the VAX. This latter feature has been used extensively by MRL staff for their research activities.

In the rock mechanics/mining application studies, engineering equations were formulated for predicting pillar loads for underground service/garage stations. A cooperative research project to evaluate mine stability has been developed with Detour Lake Mines. MRL will participate in the determination of mine rock properties, in situ stress measurements and numerical modelling. Work on in situ measurements and first phase laboratory tests have been completed.

Under the Federal/Manitoba MDA projects, the needs for R & D in the area of mining technology were identified through a series of discus-

sions with officials of various Manitoba mines, and with representatives from Manitoba Department of Energy and Mines. Six tasks, for a total of $1.61M, were proposed. Documents regarding work statements and requests for proposals were prepared for submission to DSS. Currently, four of the six tasks have been negotiated and signed. Two other tasks have been approved in principle by the MDA Management Committee, but they require additional input from Manitoba mining industry. Contract work on underground communications systems (Task No. 1), and ground stability evaluation with particular reference to a multi-lensed orebody (Task No. 2) commenced at Ruttan Mine of Sherritt Gordon in February 1985. Contract work on VBM design guidelines (Task No. 3) and geomechanical database system and numerical modelling packages (Task No. 4) were also initiated in March 1985, at INCO, Thompson, Manitoba.

2. Mine and Regional Stability

Project Leader: D.G.F. Hedley

Objectives

1. To investigate underground stability, including rockbursts, when high stresses are the major cause of failure; and

2. To study, using instrumentation, empirical and computer models, alternative mining layouts and sequences of extraction which could alleviate those failures.

Background

High ground stresses are encountered in mines at depth and where relatively high extraction ratios concentrate the field stresses. The end result of these high stresses can be pillar or wall failures, either gradually or violently in the form of rockbursts. In the past three years, fourteen hard rock mines in Northern Ontario have experienced rockbursts. The rock mechanics tools available to evaluate these high-stress problems are: seismic monitoring to locate rockbursts/seismic events and the relative seismic energy liberated; numerical modelling techniques to identify areas of high stress concentration and magnitudes of the energy components; and in situ measurement of stress and displacement to verify modelling predictions.

Achievements

A case history of the rockbursts at the Quirke Mine in Elliot Lake in March 1982 was presented at an International Symposium on Underground Stability at Lexington, Kentucky in August 1984. Presentations of this case history were also made to: Witwatersrand, McGill, Queen's and Toronto Universities, as well as to a meeting of the Professional Engineers of Ontario.

A similar case history has been written on the rockbursts at Campbell Red Lake Mine in December 1983. This was presented at a Rockburst Seminar in Sudbury in March 1985. The sequence, causes, and mechanism of rockbursts at this mine were analyzed using data from the mine's microseismic network and numerical modelling techniques. Large rockbursts were confined to sill pillars which were 6 m wide. The violence of the failures was attributed to the sudden changes in the potential energies of the hanging wall and the footwall which occurred at the moment of pillar failure.

In May 1984, a meeting was held with representatives of all of the hardrock mines in Ontario to present CANMET's proposals to increase rockburst research under a Federal/Ontario Mineral Development Agreement. Because of the increased rockburst activity afterwards during the year, these proposals were revised and expanded to include basic research on seismic monitoring.

Subsequently, at the request of Falconbridge Ltd. and INCO Ltd., scientists from the Elliot Lake Laboratory played a leading role in the technical committees set up by the companies to investigate rockbursts which occurred at the Falconbridge Mine on June 20, 1984, and at the Creighton Mine on July 6, 1984.

At the Falconbridge Mine, it was determined that the rockbursts were caused by a fault-slippage mechanism. Further mining in the area could reactivate this mechanism and, partly as a result of this, the mine was closed. A scientist at the Elliot Lake Laboratory was the chief technical witness at the subsequent inquest on the four fatalities that occurred as a result of the rockbursts at Falconbridge Mine.

In the case of the Creighton Mine, it was determined that the first major rockburst, of magnitude 4.0, rather than occurring 8 km north of the mine as originally thought, in fact occurred 150 m from the hanging wall above a subsiding area of the mine. This first major rockburst altered the stress regime and resulted in a series of aftershocks which damaged the access opening around No. 5 shaft. Subsequently, this area of the mine was closed.

In September 1984, Quirke Mine at Elliot Lake again became seismically active. Some 60 rockbursts were recorded during the subsequent six-month period. An update on this activity is to be presented at the Rockburst Seminar in Sudbury.

Late in the fiscal year, in March 1985, scientists and management personnel from CANMET/MRL also presented a brief and other assistance to the Provincial Inquiry into Ground Control and Emergency Procedures in Ontario Mines (Stevenson Commission).

Another aspect of this project has been to measure pre-mining stresses in rockburst-prone mines. This information is a prerequisite for

numerical models to determine stress distributions due to mining. Stress measurements taken at the Stanleigh Mine at Elliot Lake indicated an East/West horizontal stress twice the vertical stress. Evidence of core discing and spalling in vertical exploration drill holes confirmed this principal stress direction. The high horizontal stress is the main reason for roof failures at this mine.

Field stresses were also measured at the Macassa Mine, in Kirkland Lake, at depths of 1580 and 1890 m. Again, horizontal stresses were 1.1 to 1.5 times the vertical stress, with the North/South stress being the principal stress direction.

Measurements in both mines are comparable with measurements in other mines in the Canadian Shield.

Simultaneous testing of multiple specimens in a stiff testing machine has been initiated. It has been shown that rock specimens can fail sequentially without violence. These results help to explain the post-failure behaviour of mine pillars.

3. Rock Mass Characterization

Project Leader: G. Swan

Objectives

1. To investigate underground stability where geological structure and gravitational forces are the major cause of failure; and

2. To develop empirical, statistical and deterministic models to predict stable structures.

Background

The evaluation of stability and support requirements in underground mines would be enhanced by the availability of a comprehensive rock-mass characterization system. Similar systems have been developed over the years to meet civil engineering requirements, however, these have limited application in the large, multiple openings common in mining. Also, there is only a vague understanding of how the rock mass interacts with support systems such as backfill.

It is recognized that some specific structures in mining have special stability and support requirements. In these cases, such as for surface crown pillars, specialized rock mass characterization systems are required.

Achievements

Research on mine backfills has continued, with emphasis on the use of dewatered tailings, and replacement of tailings by rockfill, and sand-gravel. Mines using these aggregate substitute materials stand to gain both cement economies and improved design confidence from guidelines currently being worked out by CANMET. Some results from this work will be published in the CIM Bulletin.

The susceptibility of a cemented dewatered fine tailings backfill to liquifaction was investigated by a field trial at the Dome Mine, Timmins. Cemented bulkhead plugs of dewatered material are, it seems, both a safe and an economic prospect where percolation in the bulk fill material is not required.

The rock mass characterization project has received renewed impetus in the light of urgent requests from industry, particularly in Québec, for design guidelines related to surface crown pillars. During 1984, detailed field observations were made of weathered/structured rock comprising the surface pillar at Les Mines Selbaie, Québec. A decision was made to perform specialized contract work at this mine and thereby obtain the stability requirements and feasibility of some alternative methods of mining crown pillars. A service contract has provided CANMET with a computer-based core-logging system. This provides, potentially, a systematic means to establish a data base for rock mass characterizations.

Basic research on joint behaviour has resulted in the finding of serious objections to the so-called Barton-Bandis joint model. Of major concern is the nature of the roughness scale effect. The subject is discussed in some detail in a paper to be published in "Rock Mechanics and Rock Engineering".

4. Rock Properties and Support Systems

Project Leader: M. Gyenge

Objectives

1. To establish, through theoretical and experimental studies, the requirements, procedures, techniques, and specifications for laboratory and field material testing, which are essential for stability analyses and the design of mine support systems;

2. To evaluate the limitations and effectiveness of present and proposed support systems for use in deep mining under high-stress conditions; and

3. To carry out laboratory investigations related to material model development and other projects. Specific contributions of the project to long-term objectives are indicated by some of the milestones below.

Background

An increasing portion of Canadian underground mining in the future will take place under high stress. Under such conditions, the post-failure strength and deformational properties of the rock materials must be taken into consideration for design.

The requirements for ground support under these deep mining conditions requires research. The effectiveness and limitations of present underground support systems need to be established. New methods of support must be developed.

The increased accuracy and sophistication of analyses related to mine design, requires that more exact constitutive equations concerning rock strength and deformation properties must be developed. New test methods and procedures must be developed to permit laboratory determinations of the required properties.

Achievements

To establish the frictional and strength properties of rock joints, a novel testing concept has been employed. This new method can be used to determine the joint properties for simulated underground stress conditions. The test method is being referred to as "confined shear testing technique".

Following the design, in-house manufacturing and calibration, the test apparatus was used in determining the joint properties of a wide range of rock types. The results of the completed test program revealed that the method is far superior to any previous shear testing technique. Due to the inherent advantages of the applied concept, a large quantity of highly-reliable data on the joint properties can be obtained from a single set of test specimens.

Based on the reliable and consistent test data, it is possible to define the various frictional components and the relationships between these components and the stresses. Furthermore, the relationship between the strength properties of joints and rock substance can also be established.

The test apparatus, due to its simplicity, can be used at the mine sites. The possibility of patent application is being considered.

SUB-SUB ACTIVITY: MINE ENVIRONMENT

RESOURCES

Person-years:	14.5
Capital:	$399 K*
Operating:	$34 K
Contracts:	$391 K

*includes $3947 for new laboratory at Elliot Lake

PROJECTS & OUTPUTS

1. Diesel Emissions Impact and Control

Project Leader: E.D. Dainty

Objectives

To develop and encourage the adoption of technology for the improvement of the quality of underground mine environment, specifically:

1. By 1986, to demonstrate diesel emissions toxicity reduction devices underground; and
2. By 1988, to finalize the form of the Air Quality Index (AQI) expression for ventilation prescription and environmental assessment.

Background

This project incorporates two elements: (1) diesel emissions control, and; (2) health impact R & D. These relate ultimately to the certification of diesel equipment, which process requires specification of ventilation for each piece of equipment for the benefit of the provincial inspectorates. This, in turn, requires exhaust emissions testing, and the assessment of comprehensive diesel emissions direct toxicity and health impacts. The criterion developed as a measure of this is the "Air Quality Index (AQI)" which now permits rational ventilation assessment and relative assessment of engines and emissions reduction devices designed to improve environments or reduce ventilation costs. Ventilation and monitoring are necessary parallel studies to assist both mines inspectorates and mine managements in assessing compliance of the underground environment with the health criteria in force.

Achievements

The year 1984-1985, in general, has been a year of unusually significant and positive research results for this work. The processes of effective technology transfer of these results to the private sector has begun, in collaboration with the CANMET Office of Technology Transfer (OTT) and the Ontario Research Foundation (ORF). The highlights of these two areas of work are as follows:

(a) Diesel Emissions Control

In the laboratory, by both in-house and contracted-out research and development, the effectiveness of Cu/Mn fuel additives has been assessed, the principles of electric regeneration of filters has been demonstrated, and a water-conserving recirculation system for a Venturi-type high-efficiency water scrubbing system has been demonstrated.

The inexpensive Cu/Mn fuel additive, used in conjunction with the Corning ceramic filter element, has been shown to effectively reduce the unassisted auto regeneration temperature of soot from 496°C to 349°C. This reduction provides laboratory data to suggest the applicability of such filter systems to an estimated 60% of the 4000 underground mining dieselized fleet in Canada.

CANMET has developed an electrical regeneration system to combust the soot, should the filter back pressure increase, such as after the 850 hour test at INCO, described below, or any other infrequent such occurrence. The principle was demonstrated at CANMET and confirmed at ORF with both auto-regenerating and additive-assisted filters. Stress analysis showed that this system is suitable for infrequent regeneration of on-board, the machine with a minimum of time and effort. Recent discussions with INCO suggest that such a system and procedure would be acceptable to the industry.

A viable, cheap, wet-type soot filter, enabling most of water injected into the CANMET Venturi water scrubbing system to be recycled, thus significantly reducing water consumption, was developed during the latter part of this year. This makes the Venturi scrubber system more attractive, particularly for possible export by Jarvis Clark under EMR/CANMET license.

The INCO-Ontario Research Foundation study on the use of a diesel-fuel methanol emulsion as an underground fuel has been completed. Results were reported to the "Sixth International Symposium on Alcohol Fuel Technology". The work achieved the twin goals of reduction of emissions and substitution of a non-petroleum-based fuel in a geographically confined area. Satisfactory engine operation, however, required the addition of a combustion improver, resulting in an overall marginal economic impact. Exploitation of the technique would therefore only occur in response to a conventional fuel shortfall, or subsidized or lower cost additive.

Work is proceeding on laboratory and underground evaluation of a 100% methanol engine developed by Deutz, Germany. This will be an attractive underground option if a scarcity of low-sulphur diesel fuel develops in response to U.S. regulatory pressures.

In the field, two unfunded collaborative studies have yielded significant results relating beneficially to the exploitation of ceramic filters. The first is the application of simple unassisted filters to heavily-loaded LHD machines at INCO's Little Stokie Mine. Two sets of filters have reached 850 hour of untended, unassisted passive operation. Such positive environmental results were evident that the miners were reluctant to see the removal of the systems for further off-machine study and examination. Such simple systems appear applicable to high exhaust temperature applications such as most LHD machines and others used in special circumstances such as upgrade operation (i.e., including up to perhaps 1000 machines).

The second major field study was conducted at Cominco's Sullivan Mine in Kimberley, B.C. This study compared the relative impacts on the environment of a catalytic purifier and the fuel additive-assisted Corning ceramic filter. The filter system reduced the measured toxicity of the LHD operator's environment by a very significant 75%, using the AQI criteria. Such large improvements can significantly increase productivity when the use of diesels is limited by ventilation, or can significantly reduce ventilation costs.

All of the above capability plus other work has been reported to the industry via a number of recent papers presented to and/or published by: the Intergovernment Collaborative Panel (USBM/MOU/CANMET) presented to the XXIst International Conference of Safety in Mines Research Institutes in Sydney, Australia (1985) and the International SAE Congress in Detroit (1985), and the Mines Accident Prevention Association of Ontario. Further demonstrations and technology transfer projects in progress in 1985/86 are designed to identify a private sector firm to build filtration systems and to provide application engineering services to the Canadian and overseas mining industries in the short-term, and perhaps to service buses and trucks in the mid and long-terms.

(b) Health Impact R & D

Comprehensive Ames mutagenicity testing of all filter regeneration options has been undertaken. These tests show that all regenerating filters, regardless of regeneration method, emit less mutagenicity than the present widely-used catalytic purifier and, in most cases, significantly less than untreated exhaust emissions from the widely-respected "low-emissions" Deutz mining diesel engines. It seems, therefore, that the filtration approach is not likely to produce concern with respect to cancer incidence. The contract to determine the cause of the huge (up to 500 times) increase in the underground mutagen levels observed with a widely-used pelletted purifier is currently underway. This represents one of the few remaining loose ends in the underground mutagenicity studies.

Phenomenally good correlations have been achieved between laboratory and mine contracted studies of the Johnson Matthey Catalytic Trap Oxidizer. The work has identified the advantages (reduction in soot, mutagens, polynuclear aromatic hydrocarbons, aldehydes, and carbon monoxide) and disadvantages (mainly oxidation of sulphur dioxide to the potentially more toxic sulphur trioxide) of this unit, and was reported to the SAE Congress in February, 1985. The studies (laboratory and underground) provide mine operators with a thoroughly documented guide to the circumstances in which selection of this emission control option would be indicated.

A contract to evaluate the health implications of polynuclear aromatic hydrocarbon levels which have been determined in the air of a variety of dieselized underground mines is underway. The interested parties (mine operators, unions, Ontario Ministry of Labour) have agreed on a contractor - Dr. David Muir, Director of the Occupational Health Program, McMaster University.

The diesel health effects contractor, Ian W. French and Associates, has completed the massive (564 pages, 494 references) update contract. The huge US DOT/EPA/GM research effort (1978-83) has supported the contractor's 1977 conclusions, including formulation of the AQI relationship. More than 120 registrants (including representatives of most of the major mine operators in Canada, their unions, provincial regulatory bodies, mining equipment manufacturers, and several U.S. government agencies) attended the contractor's "Diesel Exhaust and the Miner's Health" Symposia in Toronto and Vancouver.

2. Radiation

Project Leader: J. Bigu

Objectives

1. To develop and test radiation instrumentation and to undertake radiation studies leading to: (a) control of radiation, and (b) better assessment of personal radiation dose exposure;

2. By 1985, to quantify by alpha- and gamma-spectroscopy, long-lived radioactive dust; and

3. By 1988, to establish a national test facility for radon, thoron and their decay products.

Background

Uranium mining is only recommended if the radiation dose to workers is within acceptable limits. Radiation dose can be controlled basically by limiting the time of exposure, protecting the worker (e.g., shielding), and by reducing the radiation level. Mechanical (i.e., forced) venti-

lation is one quite effective way of reducing radiation levels at working sites. However, there are other methods that may prove to be both effective and economical in helping to control and/or minimize radiation levels. Such methods include: (a) coating mine walls with certain chemical agents (sealants) to reduce radon (thoron) migration through mine walls; (b) use of mixing fans to eliminate decay products by plate-out on the fan blades and on wall surfaces due to convective air currents set up by the fan; (c) use of DC electric fields to remove decay products by electrostatic precipitation; (d) use, in certain cases, of special "loose" filter materials with electret properties to remove decay products by mechanical trapping and electrostatic precipitation.

From the above, it is apparent that the ability to determine radiation levels and potential exposure dose to workers is of the utmost importance from the health physics, occupational and engineering standpoints. Hence, the need to operate reliable instrumentation, under adverse environmental conditions, that provide an accurate picture of underground radiation conditions (e.g., radon and thoron and their daughter products) in real time on a continuous and unattended basis, on command.

In addition, it is also apparent that the need exists for monitoring radon and thoron daughter levels at a personal level for adequate radiation exposure determination purposes and hence the need for rugged, reliable and portable personal dosimeters. Furthermore, reliable experimental radiation data depend very much on adequate performance of measuring instrumentation. Hence, proper testing and calibration procedures of radiation instrumentation cannot be emphasized enough. In this light, the establishment of a large test facility for radon, thoron and their decay products is indispensable.

Finally, the International Commission on Radiological Protection (ICRP) has recently made recommendations regarding limits of exposure to long-lived radioactive dust in relation to total dose exposure to external gamma-radiation and airborne alpha-emitters (i.e., radon and thoron daughters in the submicron and respirable range). Hence, identification and quantification of long-lived radioactive dust has become an important issue.

Achievements

New instrumentation (monitors) suitable for continuous monitoring of: (a) the decay products of radon and thoron; and (b) radon gas have been developed, but these are still in the prototype stage.

A condensation nuclei counter/data logger has been developed for continuous monitoring of aerosols in the submicron range.

The instrumentation mentioned above must be calibrated, the performance assessed, and the applicability in mines determined. Some of this instrumentation is intended to be compatible with the Conspec system, which involves telemetering data to surface and subsequent computer processing.

Laboratory work was done on the removal of radon and thoron daughters by DC electric fields and ion generators.

Field measurements were conducted of long-lived radioactive dust in the submicron and respirable ranges.

Laboratory and field measurements were made of radon and thoron daughter attachment rates to surfaces and deposition velocities, i.e., plate-out on mine walls.

Field measurements of the electric characteristics of radon and thoron daughters were conducted.

Field measurements on radiation and dust levels induced by underground backfilling operations were conducted.

Development of radiation/ventilation mine models suitable for steady-state and time-dependent conditions continued.

The design was completed of a radon/thoron test facility (RTTF) for simulation studies, testing and calibration of radiation instrumentation was completed. This will be the National Test Facility for radon/thoron and their decay products to be built at the new Elliot Lake Laboratory.

Several reports and papers related to the above topics have been published.

3. Respirable Dust

Project Leader: G. Knight

Objectives

1. By 1985, to measure the current levels of respirable dust in Elliot Lake uranium and Labrador iron ore mines and mills;
2. By 1989, to characterize the dust produced by the major dust sources in hardrock mines in Canada, and to assess dust control;
3. By 1988, to develop dust measurement systems for silica, asbestos, and other particulates; and
4. By 1986, to identify and assess non-asbestos Canadian mines with substantial concentrations of airborne mineral fibre.

Background

Dust is a significant factor affecting both the comfort and long-term health of the work force in all mining operations. Dust from certain minerals can lead to lung disease. Lubricating oil mists and diesel exhaust also carry noxious dust and gases. In addition, in uranium mines, dust particles can carry radon and thoron daughters and long-lived radionuclides into the lungs and gut where radiation, mostly alpha-particles emitted internally, may give rise to tissue damage.

There is a need to develop measurement techniques, i.e., instrumentation and programs to better assess and predict personal dust exposure, recognizing the well-established experimental fact that dust levels vary considerably for different mining operations. Furthermore, large spatio-temporal fluctuations in the dust level, within a given mining operation, quite frequently occur. The origin of respirable dust, and its composition and size distribution, among other factors, must be known in order to determine effective control measures and to guide and interpret epidemiological and medical studies. This work requires developing an extensive database through sampling in mines with improved dust instrumentation. It also requires adequate test and calibration facilities in order to determine the accuracy of dust instrumentation.

Control measure efforts centre on improving breakage and rock handling techniques to minimize dispersion of dust into the air, filtration of airborne dust, wetting techniques, as well as optimizing mine layout and ventilation. Ultimately, optimum control requires appropriate dust suppression and control methods to be built directly into mine equipment and mining methods.

Achievements

Instrument monitors suitable for continuous monitoring of mineral, diesel and fibrous dust have been developed, but these are still in the prototype stage. As for the instruments mentioned in the previous section, calibration, assessments of performances and assessments of applicability in mines are required. Also, as mentioned previously, the monitors are to be compatible with the Conspec system for telemetering to surface and subsequent computer processing.

Dust sampling programs for assessment of individual exposure have been developed. Further refinement is necessary, directed particularly towards the low dust levels that are likely to be achieved in mines as control techniques improve.

The first stage in studies of dust control was to quantify the major dust sources in hard rock mines. It has been shown that blasting, crushing and rock handling are the major dust sources. Loading rock is the main source of dust exposure in the extractive areas of the mine.

The design of a dust test facility (DTF) has been completed. The DTF will be built at the new Elliot Lake Laboratory.

A laboratory study aimed at investigating the wetting of sulphide ores for dust control purposes is in progress.

Several reports and papers related to the above items have been published.

4. Noise and Vibration

Project Leader: M.U. Savich

Objectives

1. By 1985, to identify and quantify the major sources of noise and vibration in mines which could present a health hazard to mine workers; and

2. To permit the development of suitable technology to reduce such hazards.

Background

Over ten years ago, intensive work in Canadian mines began on personal hearing protection and audiometric tests. Noise measurements have become frequent. The Elliot Lake Laboratory techniques and experience were transferred to Canadian mines through publications or assistance in measurements.

Achievements

The main effort is now being made in personal noise dosimetry. The new generation of dosimeters automatically gives all statistical data and integrates the amplitude distribution histogram and level (L_{OSHA}) or (L_{eq} - ISO) versus time(s) graph. The Noise Exposure Index (NEI) is outlined as follows: full information of NEI is provided for the worker, management, union and environmental office. The system exemplifies the important role of the computer program. The computer could even write the report.

Noise measurements at four Falconbridge mines (Falconbridge, Strathcona, Fraser and Lockerby) were directed towards the following objectives:

(a) personal protection using practical and theoretical evaluation of all aspects of noise;

(b) measurement of the (NEI) according to the International Standards regulation (ISO3 db step) and possible comparison with the Occupational Safety and Health Act (OSHA - 5 db step); and

(c) To obtain a large number of frequency analyses and statistical analyses to evaluate the efficiency of ear muffs and to control noise exposure levels for all occupations.

These investigations were completed, and several reports are in preparation.

5. Environment Monitoring and Control

Project Leader: E.D. Dainty

Objective

To consolidate and maintain, on a continuing basis, in-house expertise in ventilation theory and practice in order to affect improvements in measurements and systems in Canadian mines.

Background

Establishment of the AQI as a ventilation criterion necessitates the development of analysis and monitoring equipment for reasons of environment control by the mine operators and health compliance by the inspectorates. The measurement thrust undertaken is the development and deployment of a portable analytical system which will be used to carry out specific measurements in the course of R & D studies initiated by CANMET with mine collaboration, and the demonstrate the means of making such measurements to the operators and inspectors.

The umbrella under which all of the above rests, is ventilation. Consequently, it is important that ventilation theory and practice be understood in order to make best use of the above R & D avenues.

Achievements

Proper planning of mine ventilation systems is essential for effective control of the various pollutants produced in mining operations. Modern mines are highly mechanized and involve working at greater depths. Methods should be found to reduce the pollutants and to use the ventilating air more effectively, especially when the power costs to move the air is mines is increasing. Basically, this project is divided into two parts. The first part deals with the application of computer techniques to plan the ventilation. The second part deals with the monitoring and control of diesel pollutants using the advanced control technology.

A report entitled "Computer techniques to simulate climatic conditions in mines", MRP/MRL 84-117(TR) was written to review the available computer models for the prediction of cooling and ventilation requirements. A program of field measurement work to determine airway friction factors in various Canadian mines was completed through a contract, and the findings will be presented in 1985 at the 2nd U.S. Mine Ventilation Symposium. The previously-developed CANMET thermodynamic model was supplied to various organizations in Canada, and abroad, to transfer the technology. The design of a ventilation system for the Ruttan deepening project, based on the CANMET model, will also be presented by Sherritt Gordon Mines Ltd. at the U.S. symposium. A report entitled "Ventilation and refrigeration requirements and costs in deep Canadian mines", MRP/MRL 84-102(J) was completed for external publication.

An extensive series of field measurements for air quality in the dieselized section of Cominco's Sullivan Mine was completed. Included in this study were the effects on mine air quality of replacing the PTX catalytic convertors on the LHD by recently-developed ceramic filter traps, and copper/manganese additive in the fuel. This study showed a dramatic reduction in the critical diesel pollutants. For example, LHD-produced NO_2 was reduced by 90%, respirable combustible dust (RCD) by 95%, and Air Quality Index (AQI) by 75%. Such a reduction in diesel pollutants by using ceramic traps with fuel additive will require less ventilation to meet the various diesel pollutant concentration limits. A paper entitled "Evaluation of diesel emissions control technology at Cominco's Sullivan Mine", MRP/MRL 85-56(OP-J) was presented in Victoria, February 1985. This, which is a significant contribution to the field, is to be published in the proceedings. The application of a monitoring system used for diesel pollutant measurements technology was presented at the Diesel Emissions Transfer Technology Seminar to potash mines in Saskatchewan, October 1984. A study to assess the effects of diesel emissions on air quality in a potash mine was completed through a contract. The diesel air quality study in other mines is to be continued in 1985/86. The study of the Conspec continuous and various environmental sensors was not completed due to the lack of space in CEAL, and a planned transfer of the work to the Elliot Lake Laboratory.

SUB-SUB ACTIVITY: ENVIRONMENTAL TECHNOLOGY

RESOURCES

Person-years:	3.15
Capital:	$20 k
Operating:	$16 k
Contracts:	-

PROJECTS & OUTPUTS

1. Solution Transport and Contaminant Migration from Tailings

Project Leader: N.K. Davé

Objective

To develop methods of tailings treatment, disposal and surface stabilization of inactive tailings piles to reduce the detrimental effects of contaminant transport via surface runoff, ground water infiltration as subsurface seepage and surface erosion by wind and water.

Background

There are envrionmental problems associated with managing mine/mill waste containing metal sulphides (such as pyrite, marcasite and pyrrhotite in tailings) which oxidize in the presence of moisture, oxygen and iron-oxidizing bacteria - thiobacilli ferro-oxidants. The oxidation produces highly-acidic conditions within the tailings, which subsequently leaches many residual metals (and trace radionuclides in uranium tailings) from the tailings material producing highly acidic, high total dissolved solids, tailings porewater. With precipitation and recharge events, these oxidation reaction products can migrate from the tailings with surface run-off and as subsurface seepage to the surrounding environment, thereby affecting the natural quality of the area water system if control methods were not used. To control wind and water erosion, many inactive tailings sites have been successfully stabilized by revegetation which has greatly improved the aesthetics and, to a certain extent, the amount of water percolating through because of increased evapotranspiration. The overall impact of revegetation on quality and quantity of effluent from reclaimed tailings areas has yet to be determined. CANMET's research objectives are to develop an effective technology of tailings disposal and management to minimize environmental impact.

Achievements

The ongoing work at the Nordic tailings site in Elliot Lake dealt with the migration of contaminants from pyritic uranium tailings. On a yearly basis, measurements are taken within the tailings and the containment plume area to monitor advancement of leached products along the groundwater flow paths. Work has been completed on the installation of flumes and continuous flow measuring instruments at various sites in the tailings area to establish a water balance.

Work has been completed on flood and trickle leaching of various mixtures of crushed rock from heap leached pyritic uranium wastes and iron hydroxide gypsum sludge. The data are being analyzed. Preliminary results show that no pyrite is oxidized even in trickle leached conditions.

In all of the test columns, the pH of the leached solutions increased with time indicating acid consuming rather than producing conditions.

Radon exhalation rates were measured for vegetated and unvegetated uranium tailings using charcoal canisters, accumulators and an aerodynamic method (by contract). The results showed spatial variations and dependence on various physical parameters such as moisture content, grain size, Ra-226 concentration, temperature and pressure. Between vegetated and unvegetated areas, no difference in radon exhalation rates was observed.

Preliminary field investigations were also conducted at the Waite-Amulet and Quemont tailings sites in Noranda-Rouyn, Quebec, to start a five-year industry-CANMET joint study dealing with the reactive tailings program. Under a separate contract, work has also been initiated at the Sullivan concentrator site of Cominco Ltd., Kimberley, B.C. to investigate the reclamation potential of highly-reactive tailings using float rock and gypsum.

Studies of contaminants uptake by vegetation, established herbivores, insectivores and other food chain members are also being conducted at various tailings sites. Samples have been collected and are being analyzed.

PART III

ENERGY TECHNOLOGY

SUB-SUB ACTIVITY: COAL MINING HEALTH & SAFETY

RESOURCES

Person-years:	5.0
Capital:	$45 K
Operating:	$65 K
Contracts:	$320 K

PROJECTS & OUTPUTS

1. Coal Mine Health and Safety R & D

Project Leader: E.D. Dainty

Objectives

To develop and encourage the adoption of technology for the improvement of the underground mine environment by reduction of safety and health risks to workers due to the presence of respirable dust and soot, toxic gaseous diesel emissions and explosive concentrations of methane and coal dust, specifically:

1. By 1986, to demonstrate diesel emissions reduction devices underground;
2. By 1987, to commission a larger-scale coal dust explosion characterizing chamber; and
3. By 1988, to commission new apparatus for electrostatic, flammability and impact ignition testing and to finalize the AQI formula.

Background

Major coal mine disasters occur around the world at a frequency of one or two per year. Canada has had its share of such disasters, the latest being in Colliery No. 26 Cape Breton in 1978 in which 12 men were killed by a methane/coal dust explosion generated by methane ignited by coal cutting picks.

Such disasters and a myriad of lesser magnitude but cumulatively significant incidents require vigilance in a number of health and safety areas including development of improved technology. These areas include: (1) diesel emissions control, (2) health impact R & D, (3) ventilation and environment monitoring, (4) fire and gas explosion phenomena R & D, and (5) dust explosion phenomena R & D.

Achievements

Diesel emissions control and health impact R & D

These are identical elements to those which have been previously described for Diesel Emissions Impact & Control: the background is identical as are the descriptions for elements (1) and (2) respectively. All of these are generally as applicable to coal operations as to non-coal workings. Essentially, water scrubber and water/oil emulsion fuel systems development are particularly compatible with safety in coal mines. Therefore, these developments are considered part of coal mine-related work. It is possible that, with some development work to reduce the surface temperature of the filter, it likewise will be suitable for coal mine use, acting as a flame trap in addition to its filtration function. This work is for the future however.

Further to that referred to above however, is the fact that Beaver Construction has sold the design of a flameproof underground vehicle which uses CANMET technology, for manufacture in Brazil. Three of these units which feature the CANMET-designed Hovey Scrubber have been manufactured to date.

Ventilation and environment monitoring

The description provided above for Environment Monitoring and Control applies equally to the energy program work as the principles are by and large equally applicable to coal mines as mineral mines. It should be noted that two of the mines studies in the ventilation K-factor study described above were coal mines.

Fire and gas explosion phenomena R & D

In order to define design criteria for gas explosion-resistant water scrubbers for diesel machines used in underground mines, a study was made of the deflections and strains in stiffened flat stainless steel plates resulting from gas-air explosions [Division Report 84-46(TR)]. This study complements an earlier one on unstiffened stainless steel plates. Experimental values of elastic and permanent deformation were shown to be much smaller than theoretical values; therefore thinner plates than formerly considered could be safely used. Failure of scrubbers are most likely at bolts or at welding locations rather than in the body of the plates.

The area of fire-resistant conveyor belting, flammability testing continues to be one of high interest. A paper summarizing the recent work has been prepared for the presentation to the 21st International Conference on Safety in Mines Research Institutes to be held in October 1985, in Australia. A study of the parameters involved in the small-scale flame test has been carried out [Division Report 84-105(TR)]. A round-robin study with the Mine Safety & Health Administration (U.S.) involving this test has yielded generally favourable results. A study of the long-term reproducibility of the small-scale flame test (about which some doubt has been expressed) along with some other small-scale tests has begun. A study in cooperation with a belting manufacturer has shown how the hot-plate ignition test, developed at MRL, can be used as a tool to

assist in formulating products that are capable of passing the large-scale "propane gallery" test.

Dust explosion phenomena R & D

(a) Preliminary work has been completed on confined dust explosion tests in a 15 m^3 spherical explosion chamber. The tests indicated that (i) dust dispersion using explosion caps is quite uniform, and (ii) the delay time between initiation and explosion is about 2 ms.

(b) The technique for measuring minimum energy of dust explosion, using high voltage single pulse spark ignition has been improved to increase the measurement accuracy. Part of this work was presented at the 1984 Spring Technical meeting of the Combustion Institute (Canadian Section), Fredericton, N.B.

(c) Methane content in coal seam has been studied at MRL for several years. This year, a part of the work was published in the paper "Preliminary evaluation of the methane production potential of coal seams at Greenhill's Mine, Elkford, B.C." in November 1984 CIM issue.

(d) CIFI (calculator and feature interface) and the microcomputer were interfaced to the Cambridge 720 image analyzer to facilitate the study of the dust particle shape.

(e) The second phase of a contract study by McGill University entitled "The influence of turbulance on dust explosion and the effect of methane on coal dust explosion" was completed. The results of the experiments indicated that (i) the maximum rate of overpressure rise is highly sensitive to the initial turbulance of air-dust mixture, and (ii) small additions of methane to a coal dust air mixture increases the burning rate substantially.

The testing of dust explosibility in the 20 L explosion chamber has been delayed to the next fiscal year due to incomplete installation of the chamber.

SUB-SUB ACTIVITY: COAL MINING SAFETY CERTIFICATION

RESOURCES

Person-years:	5.0
Capital:	$26 k
Operating:	$43 k
Contracts:	$30 k

PROJECTS & OUTPUTS

1. **Equipment Safety Certification**

Project Leaders: J.A. Bossert and G. Lobay

Objectives

1. To provide, on a continuing basis, a national service for the certification and quality assurance of flameproof equipment, gas detectors, and fire-resistant materials to be used in explosive atmospheres of coal mines and other dangerous industrial environments.

2. To develop appropriate new standards to meet changing conditions in industry.

Specifically, by 1985 to develop procedures for evaluation of impact and static electricity safety hazards posed by materials such as aluminum in coal mines; and by 1988, to develop means for the evaluation of safety performances of equipment and materials (such as pressure hoses) under working conditions.

Background

In 1953, the federal government established a laboratory for equipment safety certification, on a cost-recovery basis, of coal mine electrical equipment for use in explosive underground environments. This original mandate has evolved slowly over the years concurrently with developments in coal mining technology to include numerous fire-resistant materials and fluids, diesel machinery and explosive gas detection equipment in both underground and industrial hazardous locations. Research efforts to improve the quality of both the certification service and the standards utilized as the basis for such certification continues.

Thorough research of risks and safety requirements in advance of establishing standards is needed which R & D is pursuing parallel to the certification service. Thus, the laboratory must anticipate equipment, materials and mining developments years in advance to ensure that appropriate standards are available. The advent of more complex robot-like mining equipment, and undergroud mining in oil sands are future areas currently being considered.

A new trust, that of quality control follow-up by inspection is being currently developed involving in-house effort coupled with the inspection staff of CSA in accordance with an agreement signed in early 1984.

Achievements (Safety Certification)

A total of 45 certificates and amendments to certificates were issued this year or compared to 83 in the previous years, reflecting the downturn in the Canadian underground coal industry.

However, keen interest has been expressed in EMR certified conveyor belting by the Saskatchewan potash producers. Also, the Alberta Department of Labour has required EMR certification for equipment destined for use in an experimental underground tar sands project, and for plant heating equipment in natural gas compressor stations.

Certification activity is expected to increase substantially in 1985/1986 as the present certification backlog has doubled over the past three months to some 35 projects, and certificates issued in the last quarter are considerably ahead of the comparable time period in the previous year.

During 1984/1985, work was commenced on transferring all certification records to a database system on the laboratory's Sage IV computer. The changeover is expected to be completed in the first half of 1985. This database system will provide faster access to records, and easier generation of the annually-published "List of Certified Products".

A major rewrite of the policy document outlining EMR's certification and testing services was completed and will be distributed to all EMR clients as soon as it is available. This policy document provides a clear statement of the services offered by EMR, the obligation of EMR certificate holders, and other information which was previously unavailable from a single document.

Standards activities continued to be important, with staff participation in the development of the diesel equipment, conveyor belting, and blasting machine draft documents. Many standards continued to be revised and updated in response to new information, requests for clarification, and changing technology. In addition to participation in several national and international standards committees relating to specific types of equipment and products, the laboratory is also represented on the CSA Steering Committee for Electrical and Mechanical Mine Safety and the Canadian Electrical Code, Part I each of which is more generally involved with safety in the workplace, including explosive atmospheres.

Participation in all standards work is predicated on the relevance of the activity to explosive atmospheres or flammability of materials

with the major benefit aimed at, and accruing to, mine safety. Related industries (petroleum, chemical, natural gas) benefit from this work, as in many cases parallel hazards to the workplace exist.

Achievements (Safety Testing)

The safety testing project is primarily intended as a backup for the safety certification project, but contract testing is also performed for outside agencies and Canadian companies.

Contract testing work is accepted only on the basis that the equipment tested has an immediate application in Canada and consequent benefits for the Canadian workplace, or on the basis that the testing will provide benefit to a Canadian industry. With reference to the latter criterion, CEAL test reports have been used on an acceptance basis by other certification agencies.

Contract testing activity remained strong, with 34 projects being undertaken on behalf of the Canadian Standards Association, and 51 projects completed on behalf of other industrial clients. The latter total includes tests performed on products destined for the underground coal industry as well as the metal mining industry (both surface and underground), and other hazardous locations.

Fuel burning appliances for use in hazardous locations has been an area addressed through developmental testing in association with both the Canadian Standards Association, the Canadian Gas Association and the fuel burning appliance industry.

SUB-SUB ACTIVITY: URANIUM RESERVES ASSESSMENT

RESOURCES

Person-years	3.5
Capital:	$40 k
Operating:	$26 k
Contracts:	-

PROJECT & OUTPUTS

1. Uranium Reserves and Production

Project Leader: Á. Pustos

Objectives

1. To determine and report annually on economically mineable uranium reserves and associated inferred resources, as well as estimated production capacities and potential capabilities of uranium mining operations in Canada.

2. To develop and apply appropriate methodologies for the assessment of reserves and related economic evaluation.

Background

In 1974, the need for an expanding role for nuclear power in Canada was recognized. Accordingly, a policy was initiated to encourage exploration for uranium in Canada. In addition, the Uranium Resource Appraisal Group (URAG) was established, with the mandate to maintain a continuous reliable and uniform assessment of the Canadian uranium reserves, resources and productive capability, as a basis for the nuclear related aspects of the government's energy policy. To implement this, three URAG departmental subcommittees were created: the Sub-Committee on Reasonably Assured Resources (Measured and Indicated Reserves); the Sub-Committee on Estimated Additional Resources (Inferred, Prognosticated and Speculative Resources); and the Sub-Committee on Economics of Supply and Demand. The Mine Evaluation Group, (MEG), established within the organization of the Mining Research Laboratories, is responsible for the leadership of the Sub-Committee on Reasonably Assured Resources and participates in the work of the other two subcommittees.

Since its inception in 1974, MEG, on behalf of URAG, has assembled primary sampling and assaying data on relevant uranium deposits on a continuing basis. At the same time, its staff has developed required procedures for computer storage of the assembled data, as well as a variety of computer-applicable assessment methodologies for evaluation of mineral reserves and resources. MEG produces a major internal confidential report annually, which contains the current status of reasonably assured and associated inferred resources of uranium in all developed deposits in the country, regardless of whether or not these are actively producing or dormant. The report also contains the actual or estimated projected production capabilities of these deposits.

Since 1982, MEG also utilizes its accumulated expertise and its already developed computer-based resource assessment methodologies to evaluate annually one or more Canadian coal fields, where the necessary primary sampling data exist, to assess coal resources. This latter activity is carried out within the Assessment of Coal Reserves and Production, in cooperation with the Coal Research Laboratory.

Achievements

During 1984/85, MEG prepared its internal confidential report on the "Reasonably Assured and Associated Inferred Resources of Uranium in Canada as of December 31, 1983" and was submitted to URAG. In addition, it collected all the currently accumulating primary sampling and assaying data from all active uranium mining and development companies. The collected data are being utilized in the current preparation of MEG's next internal confidential report on uranium for 1984.

Two coal fields in Saskatchewan were also evaluated in 1984 by MEG. The results of this latter activity were summarized in two reports, entitled "Assessment of Recoverable Coal Resources" [Division Reports 85-36(TR) and 85-37(TR)].

The last months of the fiscal year were partially used to evaluate an experimental sampling and assaying data file, secured from Denison Mines Ltd. in order to gain specific insight on the interrelationship between assay values and core sample segment lengths in stratiform ore deposits. Those parts of the results of this exercise which are released for open publication by the mining company was presented at the CIM Annual General Meeting in Vancouver in April 22, 1985 [Division Report ERP/MRL 85-48(OP)].

SUB-SUB ACTIVITY: URANIUM MINE EVALUATION

RESOURCES

Person-years:	2.5
Capital:	-
Operating:	$29 k
Contracts:	-

PROJECT & OUTPUTS

1. **Mine Operations and Evaluation**

Project Leader: J. Pathak

Objectives

1. To evaluate mineability as well as mine operational economic criteria, for hard-rock mining situations, including existing and potential uranium mining operations in Canada.

2. To develop a computer mining cost data base, cost models and mine evaluation procedures to be available for government policy purposes and Canadian mining industry.

Background

Technical and economic evaluation of existing and potential uranium mining operations is an essential component of uranium reserve and resource assessment which has been assigned to CANMET on behalf of the Energy Policy Sector. Reliable estimates of uranium production capabilities for individual properties, plus projections of future productions, are also required as an input to export policy decision by AECB and as a contribution to "Redbook" published by NEA/IAEA.

To meet the above commitments, it is essential for CANMET to require realistic production cost data to develop adequate mine operation evaluation procedures and to establish a base of unit productivity related to existing and developing mine technologies.

The cut-off grade (COG) formula developed and controversially used by the Mine Evaluation Group has been critically examined - especially to establish accurate relationship and sensitivity between costs and COG as it is difficult to estimate, with high degree of confidence, mine operating costs. A report on COG for uranium deposits in Canada has been submitted to URAG. Also, a preliminary submission has been made on Canadian uranium production capability. It will be updated as soon as company figures are available.

Data on uranium production, mill head grades, production and milling capabilities, unit costs, etc. of Canadian uranium mines published by Commodities Research Unit (CRU) of New York have been thoroughly reviewed and critically compared with in-house estimates for the purpose of URAG submissions.

It is the basic need of the group to best estimate operating cost of a mine to make any sensible judgement on economic mineability of a deposit. Under contract, a study of Canadian mining industry capital and operating indices open pit and underground was completed and a report issued.

Development of such a comprehensive mining cost data base and related mine information will continue although it is difficult to access actual costs of an operating mine. Much of the initial impact will consist of best estimates to supplement incomplete actual cost information. Considerable time will be required to supplement such estimates with more realistic unit costs as they become available.

The information and techniques which will be developed with this project are anticipated to be valuable contributions to all organizations involved in the Canadian mining industry.

SUB-SUB ACTIVITY: GEOMECHANICS IN NUCLEAR WASTE DISPOSAL

RESOURCES

Person-years:	2.8
Capital:	$30 k
Operating:	$27 k
Contracts:	-

PROJECT & OUTPUTS

1. Underground Nuclear Waste Repository

Project Leader: A.B. Annor

Objectives

The general objective is to develop field and laboratory investigational methods, equipment and procedures to assess rock formations for high level radioactive waste disposal in terms of their thermal, mechanical and ion transport properties and to carry out related investigations on research area formations and at the planned underground research facility site. The studies carried out in research area formation and the underground research facility site will be used in pathway analysis studies related to concept assessment and in the design of the underground facility.

Background

Disposal of spent fuel rods will become a critical aspect of nuclear electricity generation. EMR's program is an integral part of a larger Atomic Energy of Canada Limited's (AECL) directed Canadian Fuel Cycle Waste Management Programs (FCWMP) to find safe and effective methods of disposing high level nuclear wastes.

The current participation of EMR in the FCWMP has evolved over the past ten years from an initial request in 1973 from AECL to EMR for geoscience advice on disposal by burial. An integrated geoscience sub-program has since been developed at EMR in support of FCWMP with current active participation by CANMET, Geological Survey of Canada (GSC) and Earth Physics Branch (EPB). The sub-program is structured into geology, geophysics and rock properties activity and is mainly focused on igneous formations.

At present, four research areas on plutonic structures located in Manitoba and Ontario are being used to investigate the concept of disposal of high level nuclear waste by burial. As well, an underground research laboratory (URL) is under construction near the Whiteshell Nuclear Research Establishment (WNRE) in Manitoba to carry out large-scale underground experiments.

Achievements

The following studies have been undertaken:

(a) conventional uniaxial elastic properties characterization of research area formations;

(b) specialized thermal/mechanical rock property investigations of select research area and URL laboratories; and

(c) the development and evaluation of a rock-joint behaviour model and associated characterization system to assess the coupled mechanical/hydraulic conductivity behaviour of rock joints.

To date, conventional uniaxial elastic properties characterization of Atikokan, Chalk River, Lac du Bonnet and East Bull Lake research area formations have been completed.

With regard to specialized thermal/mechanical rock properties, equipment and test procedures to study thermal diffusivity and thermal expansion under constraint have been developed. In addition, equipment and techniques for carrying out elevated temperature and pressure triaxial compression measurements have been developed and refined. The equipment and test procedures have been used to investigate a limited number of rock formations including, Creighton quartz diorite, Atikokan grandiorite and Lac du Bonnet granite, to fulfill specific program objectives.

At present, the thermal/mechanical rock properties studies are being directed towards the Lac du Bonnet formation at the URL site. A number of samples taken from zones closely associated with the operating levels of URL have been tested to provide data and interpretation for URL design and modelling studies.

Concerning rock joint behaviour studies, Terra Tek Inc. has developed under contract a rock joint model and associated methodology for characterizing the mechanical/hydraulic behaviour of joints from measurable core sample joint parameters. The model will eventually provide some means of estimating changes in rock joint conductivity as functions of stress and temperature. In addition, the joint model will permit the development of a rock characterization system based on the Norwegian Geotechnical Institute's (NGI) "Q" Index but suited to the assessment of candidate disposal sites.

As part of Terra Tek Inc.'s rock joint model evaluation exercise, a comprehensive field study program was conducted on URL-surface drilled core samples to gather rock joint index properties data during the summer of 1983. This study was extended to include rock joint samples from the URL shaft instrumentation holes in 1984.

Other achievements to date include: participation in the URL experimental planning activities, undertaking of technical reviews, stress measurements and grout studies, thermomechanical rock property determination of sedimentary formation, as well as participation in other activities associated with the Canadian Nuclear Fuel Waste Management Program.

APPENDIX A

PUBLICATIONS

PUBLICATIONS
(BY ACTIVITY)

ACEA - Administration of the Canada Explosives Act

CF - Confidential

ERP - Energy Research Program

INT - Internal Division Reports

J - Manuscripts for Journals and other outside publications

MRP - Mineral Research Program

MRL - Mining Research Laboratories

OP - Manuscripts for oral presentation and preprints

TR - Technical Reports

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

ACEA/MRL 84-2 (INT)	Device to measure Nonel shock tube velocities	F. Kapeller
ACEA/MRL 84-37(INT)	Non-destructive testing of explosive and pyrotechnic devices using X-ray radiography and fluoroscopy	T.R. Craig E. Contestabile
ACEA/MRL 84-37(J)	Thermal stability evaluation of high explosives by accelerating rate calorimetry	P.P. Lee R.R. Vandebeek
ACEA/MRL 84-50(CF)	Evaluation of security panels to explosive and firearm attacks	E. Contestabile T.R. Craig M.A.S. Armstrong J.D. Hamel R.R. Vandebeek
ACEA/MRL 84-88(OP,J)	Hazardous characteristics of pyrotechnic, propellant and explosive dusts	K.K. Feng R.R. Vandebeek
ACEA/MRL 84-120(J)	Use of shaped charges in mining operations	E. Contestabile T.R. Craig

MINERAL TECHNOLOGY

MRP/MRL 84-3(OP)	Diesel emission control catalysts: Friend or foe?	J.P. Mogan E.D. Dainty
MRP/MRL 84-5(TR)	Radionuclide levels within various tissues of vegetation growing on uranium tailings in Elliot Lake	N. Davé T.P. Lim N.R. Cloutier
MRP/MRL 84-7(TR)	Dust measurement and control in conveyor roadways: 1. Proposal for a research program as a basis for discussion	G. Knight
MRP/MRL 84-9(OP,J)	Potential application of advanced technology in underground hardrock mining	J. Pathak
MRP-ERP/MRL 84-12(INT)	EDP section of the 1984/85 information technology and systems plan	R. Boyle
MRP/MRL 84-13(TR)	Evaluation of a high frequency microseismic rock failure warning system in hardrock mines	P. MacDonald

MRP/MRL 84-14(J)	Radon (thoron) daughter measurements with an automated, programmable, radiation monitor	J. Bigu G. Vandrish
MRP/MRL 84-15(OP,J)	Analysis of waterline heaters used by the Canadian diamond drilling industry	L.B. Geller C.R. Watson
MRP/MRL 84-16(OP,J)	A case history of rockbursts at Elliot Lake	D.G.F. Hedley J.W. Roxburgh S.N. Muppalaneni
MRP/MRL 84-18(TR)	Progress report on "Canadian mining technology coordination project (CANMET Project 3.1.01.03)	R.J.R. Welwood
MRP/MRL 84-19(TR)	Radionuclide uptake by various plants growing on uranium tailings, Elliot Lake, Ontario	N.K. Davé T.P. Lim N.R. Cloutier
MRP/MRL 84-21(TR)	A proposed dust tunnel for the calibration of instruments 1. Initial design	S. Hardcastle
MRP/MRL 84-24(INT)	Potash mining: Contract progress review, Feb. 29, 1984	G. Herget M. Gyenge
MRP/MRL 84-26(J)	Theoretical considerations regarding the emanation of radon and thoron gasses from underground uranium mine walls	J. Bigu
MRP/MRL 84-30(INT)	Dust control in potash mines - Program for CANMET PCS mining operation for fiscal year April 1984 to March 1985	G. Knight
MRP/MRL 84-32(INT)	Annual review - Elliot Lake Laboratory	R. Tervo
MRP/MRL 84-35(TR)	Clamping force durability test	K.C. Butler M.U. Savich
MRP/MRL 84-36(TR)	The design and operation of a parallel stiff compression apparatus	B. Gorski
PRE/PRM/LRM 84-38(TR)F	Étude des descendants du radon fixes aux aerosols de taille sous-micronique	M.G. Grenier J. Bigu
MRP/MRL 84-39(OP,J)	Workplace respirable dust monitoring - Current and proposed Canadian practice	W. Bardswich W.J. Campbell G. Knight E. Moore
MRP/MRL 84-40(J)	Effect of electric fields on thoron daughter concentration (to be submitted for publication in Health Physics)	J. Bigu
MRP/MRL 84-41(J)	The use of a statistical model for estimating monthly soil temperatures in uranium tailings disposal sites	M.G. Grenier J. Bigu
MRP/MRL 84-42(INT)	Summary reports of progress on projects, Mining Research Laboratories, from 1983/84 Mining Research Laboratories Annual Report (prepared for meeting of mining subcommittee National Advisory Committee on Mining and Metallurgical Research (NACMR), Saskatoon, Saskatchewan, June 14-15, 1984	Prepared by: J. Udd G. Larocque C. Coburn
MRP/MRL 84-43(TR)	Mine design at Hattorf Mine and longwall mining of potash in France and Spain	G. Herget
MRP/MRL 84-44(TR)	A multi-shear apparatus	B. Gorski

MRP/MRL 84-45(TR)	Prediction of pillar load - Phase I - Underground service/garage stations	S. Vongpaisal N.A. Toews Y.S. Yu
MRP/MRL 84-47(TR)	Multiple failure state test results for three siltstone samples, Prince Mine, Nova Scotia	M. Bétournay
MRP/MRL 84-49(J)	New thrust in potash mining research (for submission to CIM Bulletin)	G. Herget
MRP/MRL 84-51	Cancelled.	
MRP/MRL 84-52(OP,J)	Radon daughter and thoron daughter deposition velocity and unattached fraction under laboratory-controlled conditions and in underground uranium mines	J. Bigu
MRP/MRL 84-53(TR)	Rock mass characterization around the crown pillar at Selbaie Mine, Quebec	B. Arjang
MRP/MRL 84-54(TR)	Problems and solution of environmental noise at Indusmin Ltd., Midland, Ontario	M.U. Savich
MRP/MRL 84-55(TR)	Field stress determinations at Selbaie Mine, Quebec	B. Arjang
MRP/MRL 84-58(J)	Predictions of shear behaviour of joints using profiles	G. Swan S. Zongqui
MRP/MRL 84-59(OP)	Progress during the first half of 1984 in the environment projects of the CANMET Minerals Program	J. Bigu
MRP/MRL 84-60(TR)	A radon (thoron) daughter personal alpha-dosimeter of the passive type using a diffused-junction detector and an electrostatic collector	J. Bigu A. Frattini
MRP/MRL 84-65(OP,J)	Noise attenuation with exhaust after treatment systems on a scooptram at Falconbridge's Strathcona Mine	M.U. Savich
MRP/MRL 84-68(J)	Proposal for particle size fraction definitions for health related sampling	G. Knight
MRP/MRL 84-68(J)	A passive radon/thoron daughter personal dosimeter using an electrostatic collector and a diffused-junction detector	J. Bigu R. Raz
MRP/MRL 84-69(TR)	Practical work on the noise attenuation with exhaust after treatment systems on a ST4A scooptram in Strathcona Mine, Falconbridge Ltd.	M.U. Savich J.K. Weglo
MRP/MRL 84-70(CF)	A study of flow conditions arising in horizontal coarse slurry short distance pipelining practice - A proposed Canada/FRG cooperative project	L.B. Geller F.G. Geller
MRP/MRL 84-71(J)	Longwall mining of potash	G. Herget
MRP/MRL 84-72(TR)	Dust concentrations as a function of air velocity in mines - Application of continuous dust sensors and an aerosol counter	S. Hardcastle
MRP/MRL 84-73(J)	A new approach to cemented backfill design	G. Swan
MRP/MRL 84-74(TR)	The demonstration of electrical heater regeneration of ceramic wall-flow diesel exhaust filters applied to mining machinery	E.D. Dainty J.P. Mogan
MRP/MRL 84-75(OP,J)	CANMET contribution to: Electrical regeneration of ceramic wall-flow diesel filters for underground mining applications	E.D. Dainty J.P. Mogan

MRP/MRL 84-76(TR)	Utilization of backfill support in longitudinal cut-and-fill mining	D.G.F. Hedley
MRP/MRL 84-77(TR)	Calibration procedures and protocols for radiation sampling pumps and alpha-particle scalers	M.G. Grenier A.J. Frattini
MRP/MRL 84-78(OP,J)	Comparison of respirable dust samplers for use in hard rock mines	G. Knight E. Moore
MRP/MRL 84-79(OP,J)	Comparison of dust samplers: Statistical analysis techniques	G. Knight E. Moore
MRP/MRL 84-80(TR)	Use of small mammals for biomonitoring environmental radionuclide levels around uranium mining industries	N.R. Cloutier T.P. Lim N.K. Davé
MRP/MRL 84-81(INT)	Documentation of DRUKPLT (VAX/VMS version)	N. Toews Y.S. Yu S. Vongpaisal A.S. Wong
MRP/MRL 84-82(J)	Load assumptions for underground excavations in the Canadian Shield	G. Herget
MRP/MRL 84-83(TR)	Measurement of impulse noise of vehicles at the Stanleigh Uranium Mine in Elliot Lake	M.U. Savich D. O'Connor
MRP/MRL 84-84(TR)	A proposal for a major research project on rockbursts	J.E. Udd
MRP/MRL 84-86(INT)	Compressional wave velocity, Young's Modulus, Poisson's Ratio and uniaxial compressive strength for EBL2 and EBL4 samples, from East Bull Lake	R. Jackson
MRP/MRL 84-87(TR)	Documentation of "DRAFT"	N. Toews S. Vongpaisal Y.S. Yu A.S. Wong
MRP/MRL 84-89(TR)	Strength and deformation properties of various rocks from the Springhill Coal Mine, Nova Scotia	M. Bétournay
MRP/MRL 84-90(TR)	A study of rock behaviour for the Donkin-Morien rock/support interaction contract	M. Bétournay
MRP/MRL 84-91(J)	Radon daughter and thoron daughter deposition velocity and unattached fraction under laboratory-controlled conditions and in underground uranium mines	J. Bigu
MRP/MRL 84-92(OP,J)	Gravimetric sampling: Practical problems	G. Knight
MRP/MRL 84-93(OP,J)	Removal of airborne thoron (radon) daughters on mine walls and other surfaces by convective deposition and electrostatic plate-out	J. Bigu
MRP/MRL 84-94(OP,J)	Non steady-state radiation mine models - Practical applications to personal dosimetry and environmental monitoring	J. Bigu
MRP/MRL 84-95(J)	RA-226 concentrations in blueberries (vaccinium angustifolium ait.) near an inactive uranium tailings site in Elliot Lake, Ontario, Canada	N.K. Davé T.P. Lim
MRP/MRL 84-96(TR)	Shear resistance of Selbaie Mine joints	G. Swan G. Vaillancourt L. Tirrul
MRP/MRL 84-97(TR)	A comparison of some approaches to the classification of rock masses for geotechnical purposes	J.E. Udd
MRP/MRL 84-99(OP,J)	A method for determining thoron gas concentrations	J. Bigu

MRP/MRL 84-100(J)	Studies of atmospheric fogging in underground mines [Revision of Division Report 83-33(OP)]	A.E. Hall M.K. Gangal S.B.V. Stewart
MRP/MRL 84-102(J)	Ventilation and refrigeration requirements and costs in deep Canadian mines	A.E. Hall K.E. Mathews M.K. Gangal
MRP/MRL 84-104(OP,J)	Radionuclide levels in vegetation growing on uranium tailings, Elliot Lake, Ontario	N.K. Davé N.R. Cloutier T.P. Lim
MRP-ERP/MRL 84-107(INT)	Mining Research Laboratories Annual Report	Compiled by C.A. Coburn
MRP/MRL 84-108(OP)	Progress during the second half of 1984 in the environmental projects of the CANMET minerals program	J. Bigu
MRP/MRL 84-109(TR)	Rationale for interpretation of airborne dust measurements at Copper Cliff sinter plant 1948-1963	G. Knight
MRP/MRL 84-112(OP,J)	Size distribution of airborne dust in Labrador iron mines [Revision of Division Report MRP/MRL 82-57(CF)]	G. Knight E. Moore C.W. Smith
MRP/MRL 84-113(J)	A dust sampling and assessment system - Campeds for use in hard rock mines	G. Knight
MRP/MRL 84-114(TR)	Progress report on mining technology development index	R.J.R. Welwood
MRP/MRL 84-115(OP,J)	The status of total diesel exhaust filter development for underground mines	E.D. Dainty J.P. Mogan A. Lawson E.W. Mitchell
MRP/MRL 84-117(TR)	Environmental monitoring and control computer techniques to simulate climatic conditions in mines	M.K. Gangal A.E. Hall
MRP/MRL 84-118(TR)	Acoustics week in Canada - Quebec City, 1984	M.U. Savich
MRP/MRL 84-119(TR)	Stress determinations at Stanleigh Mine, Elliot Lake, Ontario	B. Arjang

ENERGY TECHNOLOGY

ERP/MRL 84-1(INT)	Adjustable pressure controller	F. Kapeller
ERP/MRL 84-4(OP,J)	Update of water/fuel emulsification effects on diesel emissions reduction	A. Lawson H. Vergeer E. Mitchell E.D. Dainty
ERP/MRL 84-6(INT)	Triplot documentation - A ternary computer pilot program	A.S. Wong
ERP/MRL 84-8(TR)	Contract requirements for the Canadian mining industry capital and operating indices	M. Bétournay A. Boyer
ERP/MRL 84-10(OP,J)	Overview rock mechanics/rock properties	G.E. Larocque A. Annor
ERP-MRP/MRL 84-12(INT)	EDP section of the 1984/85 information technology and systems plan	R. Boyle
ERP/MRL 84-17(TR)	Special ambient temperature mechanical properties studies to determine the effects of stress release on URL core samples	R. Jackson C. Boudreau
ERP/MRL 84-20(CF)	The 3-dimensional multiple cutoff uranium reserves evaluation of Cigar Lake, S.E.R.U. Nuclear (Canada) Limited, North Saskatchewan	A. Boyer

ERP/MRL 84-22(TR)	High temperature and pressure triaxial compression tests on sample from borehole URL-6	R. Jackson
ERP/MRL 84-23(OP)	Electrical instruments for use in underground coal mines and preparation plants	J.A. Bossert K.J. Mintz
ERP/MRL 84-25(TR)	Laboratory test results of rock cores from No. 26 Colliery, Sydney coalfield	B. Gorski
ERP/MRL 84-27(TR)	Model analyses of URL-01, URL-02, URL-05 and URL-06 extended engineering core samples from the underground research laboratory site near Lac du Bonnet, Manitoba	A.S. Wong
ERP/MRL 84-28(TR)	The design and operation of a water permeability system to test rock cores at medium pressure	B. Gorski
ERP/MRL 84-29(CF)	Small-scale flammability tests on Yokohama conveyor belting	K.J. Mintz
ERP/MRL 84-31(INT)	A summary of mechanical property test data on samples from boreholes URL 7, URL B9-1, 2 and 3, URL B10-1 and URL B26-1 at Lac du Bonnet, Manitoba	R. Jackson D. Paquette
ERP/MRL 84-33(TR)	Mechanical properties of rock samples from Chalk River, Ontario	A. Annor A.S. Wong
ERP/MRL 84-34(INT)	Mechanical rock property test procedures and results for samples originating from boreholes URL 7, URL B9, URL B10 and URL B26, Lac du Bonnet, Manitoba	D. Paquette
ERP/MRL 84-46(TR)	An experimental study of a stiffened flat stainless steel plate subjected to explosion and static loading	K.J. Mintz
ERP/MRL 84-48(TR)	Mechanical properties of rock samples from Pinawa, Manitoba	A. Annor
ERP/MRL 84-57(CF)	Assessment of reasonably assured resources of uranium and inferred resources of thorium in the major deposits of thorium in the major deposits of Canada 1983	The Sub-committee on Reasonably Assured Resources, Uranium Resource Appraisal Group EMR
ERP/MRL 84-61(OP,J)	Multiple cutoff estimation of global in situ ore reserves	A. Füstös A. Boyer R. Boyle
ERP/MRL 84-62	Cancelled.	
ERP/MRL 84-63(TR)	Mechanical properties of rock samples from Atikokan, Ontario	R. Jackson
ERP/MRL 84-64(INT)	Update to draft proposal for in situ heater experiment at URL, Pinawa, Manitoba [Revision of Division Report ERP/MRL 82-83(TR)]	A. Annor
ERP/MRL 84-66(CF)	Flammability tests on Fenaplast FRSR 6000 conveyor belting	K.J. Mintz M.S. Ralph
ERP/MRL 84-85(TR)	Summary of mechanical properties of Lac du Bonnet and Eye-Dashwa specimens	R. Jackson
ERP/MRL 84-98(TR)	Emulsion stability of mine hydraulic fluids under freeze-thaw cycles	N.K. Sarin
ERP/MRL 84-101(INT)	Laboratory test results of rock cores from strata control hole #6 Donkin-Morien rock support interaction contract	B. Gorski
ERP/MRL 84-103(TR)	Cancelled.	

ERP/MRL 84-105(TR)	The EMR small-scale flame test	K.J. Mintz
ERP/MRL 84-106(INT)	Permeability testing of some mine rock samples	A. Annor
ERP-MRP/MRL 84-107(INT)	Mining Research Laboratories Annual Report	Compiled by C.A. Coburn
ERP/MRL 84-110(CF)	Tests of a thermoelectric power generator for use in potentially explosive atmospheres	G. Lobay E.D. Dainty
ERP/MRL 84-111(TR)	Laboratory test results of coal cores from Lingan Colliery	B. Gorski
ERP/MRL 84-116(CF)	Flammability testing of used Scandura belting from IMC	K.J. Mintz

ORAL PRESENTATIONS

Annor, A., Jackson, R. and Chernis, P. "The mechanical properties of rock samples from the Lac du Bonnet batholith and the Eye Dashwa Lakes pluton"; presented at the Nuclear Fuel Waste Management Geophysical Workshop, Earth Physics Branch, Energy, Mines and Resources Canada, Ottawa, Ontario, Feb. 14-15, 1985.

Bardswich, W.J., Campbell, W.J., Knight, G. and Moore, E. "Workplace respirable dust monitoring - Current and proposed Canadian practice"; presented at the VI International Pneumoconiosis Conference, Bochum, West Germany, Sept. 19-23, 1984 [Division Report MRP/MRL 84-39(OP)].

Bigu, J., Raz, R., Golden, K., and Dominguez, P. "A computer-based continuous monitor for the determination of the short-lived decay products of radon and thoron"; presented at the Health Physics Society Meeting on Computer Applications in Health Physics; mid-year topical meeting, Pasco, WA, Feb. 5-9, 1984 [Division Report MRP/MRL 83-103(OP)].

Bigu, J., Grenier, M., Davé, N., Lim, T. and Chakravatti, J. "Radon gas concentration, surface radon flux and other radiation variables from uranium mine tailings areas"; presented at the 6th Annual Symposium on Management of Uranium Mill Tailings, Low-Level Waste, and Hazardous Waste, Fort Collins, Co., Feb. 1-3, 1984 [Division Report MRP/MRL 83-104(OP)].

Bigu, J. "Progress during the first half of 1984 in the environment projects of the CANMET minerals program"; presented to the Joint Panel on Occupational and Environmental research for Uranium Production in Canada, Elliot Lake, Ontario, June 12-13, 1984 [Division Report MRP/MRL 84-59(OP)].

Bigu, J. "Radon daughter and thoron daughter deposition velocity and unattached fraction under laboratory-controlled conditions and in underground uranium mines"; presented at the 29th Annual Meeting of the Health Physics Society, New Orleans, U.S.A., June 3-8, 1984 [Division Report MRP/MRL 84-52(OP)].

Bigu, J. "Removal of airborne thoron (radon) daughters on mine walls and other surfaces by convective deposition and electrostatic plate-out"; presented at the International Conference on Occupational Radiation Safety in Mining, Toronto, Ontario, Oct. 14-18, 1984 [Division Report MRP/MRL 84-93(OP)].

Bigu, J. "Non steady-state radiation mine models - Practical applications to personal dosimetry and environmental monitoring"; presented at the International Conference on Occupational Radiation Safety in Mining, Toronto, Ontario, Oct. 14-18, 1984 [Division Report MRP/MRL 84-94(OP)].

Bigu, J. "A method for determining thoron gas concentrations; presented at the Conference on Environmental Radiation, Colorado Springs, Colorado, Jan. 6-10, 1985 [Division Report MRP/MRL 84-99(OP).

Bigu, J. "Progress during the second half of 1984 in the environmental projects of the CANMET minerals program"; presented to the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, Saskatoon, Sask., Nov. 27-28, 1984 [Division Report MRP/MRL 84-108(OP)].

Bossert, J.A. and Mintz, K.J. "Electrical instruments for use in underground coal mines and preparation plants"; presented by K.J. Mintz at the 12th Annual International Symposium of Mining & Metallurgy Division of the Instrument Society of America, Vancouver, B.C., May 2-4, 1984 [Division Report ERP/MRL 84-23(OP)].

Cheng, K.C., Contestabile, E. and Feng, K.K. "Capacitive discharge initiation of coal dust explosions"; presented at the 1984 Combustion Institute (Canadian Section) Spring Technical Meeting, Fredericton, New Brunswick, May 24-25, 1984 [Division Report ERP/MRL 82-126(OP)].

Davé, N, Lim, T. "Migration of contaminants from underwater buried uranium tailings - Laboratory investigations of Ra-226, total dissolved solids, Ca 2 and SO4-2 transfer flux"; presented at the 6th Annual Symposium on Management of Uranium Mill Tailings, Low-Level Waste, and Hazardous Waste at Fort Collins, CO, Feb. 103, 1984 [Division Report MRP/MRL 83-105(OP)].

Dainty, E.D. and Mogan, J.P. "CANMET contribution to: Electrical regeneration ceramic wall-flow diesel filters for underground mining applications"; presented at the Society of Automotive Engineers, International Congress, Detroit, Feb. 1985 [Division Report MRP/MRL 84-75(OP)].

Dainty, E.D., Mogan, J.P., Lawson, A. and Mitchell, E.W. "The status of total diesel exhaust filter development for underground mines"; presented at the XXIst ICSMR Institutes Sydney, Australia, Oct. 1985 [Division Report 84-115].

Dainty, E.D., Bourré, C. and Elliot, W.T. "Characterization of ceramic diesel exhaust filter auto-regeneration in a hardrock mine"; presented at the Mines Accident Prevention Association of Ontario, Technical Sessions of 54th Annual General Meeting, Toronto, May 29-31, 1985 [Division Report MRP/MRL 85-38(OP)].

Dainty, E.D. "CSA standard M424 - Interation No. 6 - Flameproof diesel-powered vehicles for use in gassy underground coal mines"; a CEAL document for a working group, July 1984; presented to the CSA Technical Committee, Vancouver, B.C., July 1984 [Division Report ERP/MRL 85-59(OP)].

Dainty, E.D. and Gangal, M. Made a comprehensive diesel technology presentation during a day-long diesel program to COMINCO's Sullivan Mine staff at their request. In addition, a similar day-long seminar was provided to sponsor the South Saskatchewan mining community in Saskatoon, involving some 35 special-interest staff.

Dainty, E.D. Numerous technical presentations to the collaborative advisory panel on diesel emissions reduction R & D.

Davé, N.K., Cloutier, N.R. and Lim, T.P. "Radionuclide levels in vegetation growing on uranium tailings, Elliot Lake, Ontario"; presented at the 7th Annual Symposium on Management of Uranium Mill Tailings, Low-Level Waste and Hazardous Waste, Fort Collins, CO, Feb. 6-8, 1985 [Division Report MRP/MRL 84-104(OP)].

Feng, K.K. and Vandebeek, R.R. "Hazardous characteristics of pyrotechnic, propellant and explosive dusts"; presented at the First International Colloquium on Explosibility of Industrial Dusts, Baranow, Poland, Nov. 8-10, 1984 [Division Report ACEA/MRL 84-88(OP)].

Füstös, A., Boyer, A. and Boyle, R. "Multiple cutoff estimation of global in situ ore reserves"; presented at the CIM General Meeting, Geology Division; General Session, Ottawa, Ontario, Apr. 18, 1984 [Division Report ERP/MRL 84-61(OP)].

Gangal, M.K., Dainty, E.D., Weitzel, L. and Bapty, M. "Evaluation of diesel emissions control technology at Cominco's Sullivan Mine"; presented at the 4th Mechanical/Electrical Engineering Symposium. Sponsored by the Ministry of Energy, Mines and Petroleum Resources, British Columbia, Victoria, B.C., Feb. 19-23, 1985 [Division Report MRP/MRL 85-56(OP)].

Geller, L.B. and Watson, C.R. "Analysis of waterline heaters used by the Canadian diamond drilling industry"; presented at the 41st Annual General Meeting and Convention of the Canadian Diamond Drilling Association, Niagara Falls, Ont., Apr. 25-27, 1984 [Division Report MRP/MRL 84-15(OP)].

Hedley, D.G.F., Roxburgh, J.W. and Muppalaneni, S.N. "A case history of rockbursts at Elliot Lake"; presented at the 2nd International Conference on Stability in Underground Mining, Lexington, Kentucky, Aug. 1984 [Division Report MRP/MRL 84-16(OP)].

Herget, G. "Longwall mining of potash"; presented at the CIM Annual General Meeting, Vancouver, Canada, Apr. 21-25, 1985 [Division Report MRP/MRL 84-71(OP)].

Knight, G. and Moore, E. "Comparison of respirable dust samplers for use in hardrock mines"; presented at the American Industrial Hygiene Conference, Detroit, May 21, 1984 [Division Report MRP/MRL 84-78(OP)].

Knight, G. and Moore, E. "Comparison of dust samplers: Statistical analysis techniques"; presented at the 1984 American Industrial Hygiene Conference, Detroit, May 21, 1984 [Division Report MRP/MRL 84-79(OP)].

Knight, G. "Gravimetric sampling: Practical problems"; presented at the American Industrial Hygiene Association Conference, Las Vegas, Nevada, May 21-24, 1985 [Division Report MRP/MRL 84-92(OP)].

Larocque, G.E. and Annor, A. "Overview rock mechanics/rock properties"; presented at the 17th Nuclear Fuel Waste Management Information Meeting, Carleton University, Ottawa, Ontario, Feb. 21-23, 1984 [Division Report ERP/MRL 84-10(OP)].

Lawson, A., Vergeer, H., Mitchell, E. and Dainty, E.D. "Update of water/fuel emulsification effects on diesel emissions reduction"; presented at the CIM Annual General Meeting, Ottawa, Ontario, April 1984 [Division Report ERP/MRL 84-4(OP)].

Mogan, P. Made two presentations regarding diesel emissions reduction equipment development to the I.W. French and Associates AQI technology transfer sessions held in Toronto and Vancouver. These sessions were attended by 92 and 26 people respectively, including representatives of Canadian and US governments and industries.

Mogan, J.P. and Dainty, E.D. "Diesel emission control catalysts: Friend or foe?"; presented at the CIM Annual General Meeting, Ottawa, Ontario, April 17, 1984 [Division Report MRP/MRL 84-3(OP)].

Pathak, J. "Potential application of advanced technology in underground hardrock mining"; presented at the World Mining Congress, New Delhi, India, Nov. 19-23, 1984 [Division Report MRP/MRL 84-9(OP)].

Savich, M.U. and Weglo, J.K. "Noise attenuation with exhaust after treatment systems on a scooptram at Falconbridge's Strathcona Mine"; presented at Acoustics Week in Canada, Quebec City, Oct. 22-26, 1984 [Division Report MRP/MRL 84-65(OP)].

Vergeer, H.C., Gulati, S.T., Mogan, J.P. and Dainty, E.D. "Electrical regenerations of ceramic wall-flow diesel filters for underground mining applications"; presented at the Society of Automotive Engineers International Congress, Detroit, Mich., Feb/Mar 1985.

JOURNAL PUBLICATIONS

Annor, A. and Katsube, T.J. "Nonlinear elastic characteristics of granite rock samples from Lac du Bonnet Batholith"; Current Research, Part A, Geological Survey of Canada, Paper 83-1A p 411-416, 1983.

Murray, D.R. "Soil profile development in vegetated uranium tailings"; CIM Bulletin, 77:863:106; March 1984 [Division Report MRP/MRL 82-147(J)].

Knight, G. "Rock fibre in non-asbestos mines - A suggested program for Canadian mines"; ASTM Special Technical Publication No. 834, July 1984 [Division Report MRP/MRL 83-9(J)].

Bigu, J. and Grenier, M. "Studies of radioactive dust in Canadian uranium mines"; CIM Bulletin, 77:869:62; Sept. 1984 [Division Report MRP/MRL 83-24(J)].

Bigu, J., Raz, R., Golden, K. and Dominguez, P. "Design and development of a computer-based continuous monitor for the determination of the short-lived decay products of radon and thoron"; Nuclear Instruments and Methods in Phy. Res. 225:399-406; 1984 [Division Report MRP/MRL 83-40(J)].

Bigu, J. and Grenier, M. "On the effect of a negative ion generator and a mixing fan on the attachment of thoron decay products in a thoron box"; Health Physics, 46:4:933-939; 1984 [Division Report 83-42(J)].

Bigu, J. and Roze, V. "Extended capabilities of a personal alpha-dosimeter as an environmental radon (thoron) daughter continuous monitor"; Radiation Protection Dosimetry, 8:3:173-176; 1984 [Division Report MRP/MRL 83-55(J)].

Bigu, J. and Grenier, M. "Thoron daughter working level measurements on one and two gross alpha-count methods"; Nuclear Instruments and Methods in Phys. Res. 225:285-398; 1984 [Division Report MRP/MRL 83-57(J)].

Knight, G. "Inter-laboratory crosscheck of quartz analysis on mine airborne dust samples"; Am Ind. Hyg. Assoc. J., 45:9:655-600; Sept. 1984 [Division Report MRP/MRL 83-85(J)].

Bigu, J. "Design and performance of a personal alpha-dosimeter of the passive type for radon daughters using a diffused-junction detector and an electrostatic collector"; Radiation Protection Dosimetry, 5:3:171-178; 1984 [Division Report MRP/MRL 83-71(J)].

Bigu, J. "A walk-in radon/thoron test facility"; Am. Ind. Hyg. Assoc. J., 45:8:525-232; 1984 [Division Report MRP/MRL 83-80(J)].

Knight, G. "Critical orifices"; Am. Ind. Hyg. Assoc. J., 45:11; Nov. 1984 (short note).

Knight, G. "Correlation between measurements by MRE 9(Cassella 113A) and cyclone dust sampler"; Ann. Occup. Hyg., 28:4:459; 1984.

Bigu, J., Grenier, M., Davé, N., Chakravatti, J. and Lim, T.P. "Study of radon gas concentration, surface radon flux and other radiation variables from uranium mine tailings areas"; Uranium, 1:257-277; 1984 [Division Report MRP/MRL 83-96(J)].

Herget, G. "New thrust in potash mining research"; Canadian Mining Journal; Feb. 1985; p 12 [Division Report MRP/MRL 84-49(J)].

Vergeer, H.C., Gulati, S.T., Mogan, J.P. and Dainty, E.D. "Electrical regeneration of ceramic wall-flow diesel filters for underground mining applications"; Document P-158 - Diesel Particulate Control (Paper No. 850152) published by SAE in connection with the SAE International Congress, Detroit, Feb/Mar 1985.

Lawson, A., Vergeer, H.C., Drummond, W., Mogan, J.P. and Dainty, E.D. "Performance of a ceramic diesel particulate trap over typical mining duty cycles using fuel additives"; Document P-158 - Diesel Particulate Control (Paper No. 850150) published by SAE in connection with the SAE International Congress, Detroit, Feb/Mar 1985.

Mogan, J.P., Dainty, E.D., Vergeer, H.C., Lawson, A., Westaway, K.C., Weglo, J.K. and Thomas, L.R. "Investigation of the CTO emission control system applied to heavy duty diesel engines used in underground mining equipment"; Document P-158 - Diesel Particulate Control (Paper No. 850151) published by SAE in connection with the SAE International Congress, Detroit, Feb/Mar 1985.

Feng, K.K., Cheng, K.C. and Augsten, R. "Preliminary evaluation of the methane production potential of coal seams at Greenhills Mine, Elkford, British Columbia"; CIM Bulletin, 77:871:56-61; Nov. 1984 [Division Report ERP/MRL 83-37(J)].

Feng, K.K. "Spontaneous combustion of Canadian coals"; CIM Bulletin; 78:877:71-75; May 1985 [Division Report ERP/MRL 83-100(J)].

PAPERS PUBLISHED IN CONFERENCE PROCEEDINGS

Bigu, J., Raz, R. Golden, K. and Dominguez, P. "A computer-based continuous monitor for the determination of the short-lived decay products of radon and thoron"; Proc. Health Physics Society on Computer Applications in Health Physics, Mid-year Topical Meeting, Pasco, WA, Feb. 5-9, 1984 [Division Report MRP/MRL 83-103].

Bigu, J., Grenier, M., Davé, N., Lim, T. and Chakravatti, J. "Radon gas concentration, surface radon flux and other radiation variables from uranium mine tailings areas"; Proc. 6th Annual Symp. on Management of Uranium Mill Tailings, Low-Level Waste and Hazardous Waste, Fort Collins, Colorado, Feb. 1-3, 1984, Session 4, p 211-220 [Division Report MRP/MRL 83-104].

Dainty, E.D., Bourré, C. and Elliot, W.T. "Characterization of ceramic diesel exhaust filter auto-regeneration in a hard rock mine"; Proc. of Mines Accident Prevention Association of Ontario, Technical Sessions of 54th AGM, Toronto, May 29-31, 1985 [Division Report MRP/MRL 85-38].

Davé, N. and Lim, T. "Migration of contaminants from underwater buried uranium tailings - Laboratory investigations of Ra-226, total dissolved solids, Ca2 and SO4-2 transfer flux"; Proc. 6th Annual Symp on Management of Uranium Mill Tailings, Low-Level Waste, and Hazardous Waste; Fort Collins, Colorado, Feb. 1-3, 1984 Session 3, p 83-92 [Division Report MRP/MRL 83-105].

Feng, K., and Vandebeek, R.R. "Hazardous characteristics of pyrotechnic propellant and explosive dusts"; Proc First International Colloquium on Explosibility of Industrial Dusts; Baranow, Poland, Nov. 8-10, 1984; p 83-92 [Division Report ACEA/MRL 84-88].

Gangal, M.K., Dainty, E.D., Weitzel, L. and Bapty, M. "Evaluation of diesel emissions control technology at COMINCO's Sullivan Mine"; Proc of the 4th Mechanical/Electrical Engineering Symposium sponsored by the Ministry of Energy, Mines and Petroleum Resources, British Columbia, Victoria, B.C., Feb. 1985 [Division Report MRP/MRL 85-56].

Hedley, D., Roxburgh, J. and Muppalaneni, S. "A case history of rockbursts at Elliot Lake"; Proc. Int. Conf. on Stability in Underground Mining, Lexington, Kentucky, Aug. 1984, p 210 [Division Report MRP/MRL 84-16].

Katsube, T.J. and Annor, A. "Characterization of rocks from Chalk River by non-linear elastic parameters"; Proc 1984 Nuclear Fuel Waste Management, Geophysical Workshop on Chalk River Research Area, Earth Physics Branch, EMR, Ottawa.

Pathak, J. "Potential application of advanced technology in underground hardrock mining"; Proc. of 12th World Mining Congress; New Delhi, India; Nov. 19-23, 1984; V. II, p 4.12-01-14 [Division Report MRP/MRL 84-9].

Simmons, G.R., Annor, A., Baumgartner, P., Lang, P.A., Larocque, G.E. and Wilkins, B.J.S. "The geomechanics program - a review"; Proc. 18th Information Meeting of the Nuclear Fuel Waste Management Program (1984 General Meeting), Atomic Energy of Canada Ltd. Publication T.R.-320; p 23-44; Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, 1984.

APPENDIX B

CONTRACTS AND RESEARCH AGREEMENTS

CONTRACTS
(BY ACTIVITY)

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

Title	Investigator	Scientific Authority	Total Value ($K)	CANMET expenditure (84/85 $K)	Status as of 31 March 1985
Evaluation on propagation sensitivity for commercial explosives (1-9026)	Mining Resource Engineering	R.R. Vandebeek	25.0	25.0	Complete
Theoretical model for predicting low velocity impact sensitivity bubble sensitized slurry explosives (4-9027)	Mining Resource Engineering	K.K. Feng	105.0	22.5	In progress
Interpretation and modelling of thermodynamic data generated by ARC (4-9063)	University of Ottawa	K.K. Feng	21.0	21.0	Complete
Experimental verification of high velocity impact model for slurry explosives projectile impact (4-9151)	Mining Resource Engineering	K.K. Feng	200.0	51.07	In progress

MINERALS TECHNOLOGY

Title	Investigator	Scientific Authority	Total Value ($K)	CANMET expenditure (84/85 $K)	Status as of 31 March 1985
Evaluation of effect and catalyst types, engines and load cycles on mutagenic activity diesel exhaust extracts (1-9068)	Ontario Research Foundation	P. Mogan	163.9	0.6	Complete
Development construction and testing of a prototype electro-hydraulic mini-scaler (UP-T-155) (2-9173)	Teledyne Canada Ltd.	J. Pathak	175.5	53.45	Complete
Une étude sur les pilliers de surface (UP-R-180) (3-9005)	Roche Ltée	M. Bétournay	116.8	11.6	Complete
To study the stability and supporting in deep mines (0-9063)	Falconbridge	D. Hedley	140.2	7.9	In progress
Determination of the effects of emission control devices on the polynuclear aromatic hydrocarbon and mutagen levels in dieselized underground mines (3-91753-1)	Laurentian University	P. Mogan	45.57	45.57	Complete
Investigation dust measuring techniques and identify dust levels and effects on safety etc. (3-9154)	Cambrian Engineering	G. Knight	25.4	11.5	Complete
Computer blast design for large diameter blasthole stopes in underground (UP-M-234) (3-9186)	Mining Resource Engineering	J. Pathak	50.75	27.25	Complete
Determination of the PAH partition ratio and the nature of the mutagens generated by catalytic purifiers (3-9196)	Laurentian University	P. Mogan	54.39	18.08	In progress
Development of sensor for separate assessment of diesel exhaust or mine dust (3-9091)	Metrex Instruments Inc.	G. Knight	104.2	24.2	Complete
Alternatives to present potash mining practices in Canada (3-9124)	Montreal Engineering	J. Pathak	53.86	22.80	Complete
Assessment of possible problems in regional mine stability with future mining of Saskatchewan potash (3-9125)	Potash Corporation	M. Gyenge	89.90	59.10	Complete
Creep cell evaluation and laboratory testing of large evaporite samples (3-9126)	Saskatchewan Research	L. Geller	40.0	11.0	Complete
Investigation dust measuring techniques and identification dust levels (3-9154)	Cambrian Engineering	G. Knight	25.4	11.5	Complete

CONTRACTS

MINERALS (Cont'd)

Title	Investigator	Scientific Authority	Total Value ($K)	CANMET expenditure (84/85 $K)	Status as of 31 March 1985
Development of computer program for potash mining (3-9155)	RE/SPEC Ltd.	Y.S. Yu	52.39	41.90	Complete
Investigation of computer software and hardware in surface and underground mining in Canada (3-9202)	H.A. Simons Ltd.	R. Boyle	72.55	72.55	Complete
Determination of engineering properties of waste salt backfill in Saskatchewan potash mines	RE/SPEC Ltd.	M. Bétournay	47.10	28.7	Complete
A field test program to evaluate the use of waste salt backfill in Saskatchewan potash mines (3-9206-1)	Central Potash Ltd.	G. Herget	160.0	116.6	In progress
Collection and evaluation of field data around excavations in potash (3-9206-2)	Cominco Ltd.	G. Herget	31.44	31.44	Complete
Absolute radon gas monitor (4-9021)	EDA Instruments	J. Bigu	45.95	45.95	Complete
Automated condensation nuclei monitor (4-9022)	Environment One Corp.	J. Bigu	12.20	12.20	Complete
Data acquisition system for condensation nuclei monitor (4-9022-2)	Environment One Corp.	J. Bigu	4.19	4.19	Complete
Remote radon daughter monitor to measure the decay products of radon (4-9023)	EDA Instruments	J. Bigu	52.47	52.47	Complete
Identification of underground equipment development potential and its influence on mine design (4-9070)	Brampton	J. Pathak	61.30	10.7	In progress
A study to assess the diesel emissions environment in an underground potash mine (4-9128)	J.H. Johnson	M. Gangal	34.0	34.0	Complete
Time dependent behaviour of frozen backfill pelletized tailings in underground mines (UP-M-172)(4-9129)	Nantar Engineering	M. Gyenge	41.85	29.30	In progress
A study to determine friction factors of mine airways (4-9130)	Queen's University	M. Gangal	56.30	50.6	In progress
Examination of impact of polynuclear aromatic hydrocarbon explosives in underground mines (4-9142)	McMaster University	P. Mogan	33.08	10.76	In progress

MINERALS (Cont'd)

Title	Investigator	Scientific Authority	Total Value ($K)	CANMET expenditure (84/85 $K)	Status as of 31 March 1985
R & D in Manitoba mines - Task 2: Ground stability evaluation with reference to echelon lensed orebody (4-9147-1)	Sheritt Gordon Mines	S. Vongpaisal	239.10	20.5	In progress
R & D in Manitoba mines - Task 3: Communication system for isolated areas in mines (4-9147-2)	Sheritt Gordon Mines	S. Vongpaisal	280.0	26.55	In progress
R & D in Manitoba mines - Task 4: Geomechanical data base for ground control in deep mines (4-9147-3)	Inco Ltd.	Y.S. Yu	255.55	5.39	In progress
R & D in Manitoba mines - Task 1: To develop vertical block method design guidelines for a steeply dipping orebody and to develop scaling techniques (4-9147-4)	Inco Ltd.	Y.S. Yu	362.5	3.0	In progress
Prod. of portable microprocessor controlled multi-size range aerosol counting system (4-9148)	Mono Research Labs	S. Hardcastle	104.0	64.8	In progress
Field calibrations of three new fibre measuring techniques with each other and with other existing methods (4-9153)	Metrex Instruments Inc.	G. Knight	43.0	22.32	In progress
Field calibrations of three new fibre measuring techniques with each other and with other existing methods (4-9152)	Ontario Research Foundation	G. Knight	67.0	0.8	In progress
Transfer of the findings of the diesel health effects project to the Canadian mining industry (4-9225)	Ian French & Assoc.	P. Mogan	12.74	12.74	Complete
Development of wire mesh particulate oxidizer traps using full additives (UP-E-183)(4-9230)	Engine Control Systems	E.D. Dainty	73.9	0*	In progress *15.6 (DSS)
Development of an automated routine measurement of asbestos in workplace atmospheres (4-9297)	Ontario Research Foundation	G. Knight	25.0	25.0	Complete
Reclamation study of pyritic tailings using float and gysumsullivan concentrator (4-9275)	Cominco	N. Davé	19.08	17.17	In progress
Monitor the quantities of surface water leaving a tailings area (4-9309)	Environment Canada	N. Davé	4.2	4.2	Complete

CONTRACTS

ENERGY

Title	Investigator	Scientific Authority	Total Value ($K)	CANMET expenditure (84/85 $K)	Status as of 31 March 1985
Methanol fuel as transportation in mining operations (UP-1-103)(0-9087)	Inco Ltd.	P. Mogan	349.0	38.6	Complete
Development of water recycling system for venturi water scrubber (0-9164)	Jarvis Clark Ltd.	P. Mogan	18.3	10.9	Complete
Assessment and promulgation of diesel health effects for health of underground workers (2-9062)	Ian W. French Assoc.	P. Mogan	22.0	14.6	In progress
A review of mine maintenance in Canada (UP-0-56) (3-9094)	Queen's University	R.J.R. Welwood	47.7	12.0	Complete
Conversion of CANMET CADD & GEM computer programs for computer-independent usage (3-9123)	Borealis Systems	R. Boyle	35.0	7.0	Complete
Completion of pre-trial phase of diesel emissions reduction option development (3-9169)	Ontario Research Foundation	D. Dainty	76.4	19.9	Complete
Investigation of the performance of the Johnson Matthey catalytic trap in the treatment of the exhaust from underground mines (3-9174)	Ontario Research Foundation	P. Mogan	24.9	24.9	Complete
Influence of turbulence on dust explosions and the effect of methane on coal dust air explosion (4-9024)	McGill University	E.D. Dainty	60.0	60.0	Complete
Completion of pretrial phase of diesel emissions reduction - Part II (4-9025)	Ontario Research	E.D. Dainty	177.1	169.8	In progress
Development of underground mining methods for exploitation of high grade uranium deposit (4-9139)	DSMA ACTON Ltd.	R. Clarke	90.86	38.1	In progress
Examination of the 100% methanol or pilot diesel methanol engine as a power source for underground mines (4-9166)	Inco Ltd.	P. Mogan	125.0	25.57	In progress
Canadian mining industry capital and operating indices (4-9136)	Dynatec	R. Clarke	36.1	33.8	In progress
Study of flow conditions arising in horizontal coarse slurry short distance pipelining (4-9294)	C.A. Shook Consultants	L. Geller	113.31	106.8	In progress
Modifications and provision of Jarco 500 LHD diesel machine for environmental impact trials of emissions reduction devices - Phase I (4-9326-1)	CIL Inc. (Jarvis)	E.D. Dainty	21.18	3.93	In progress

RESEARCH AGREEMENTS
(BY ACTIVITY)

Title	Investigator	Contact Officer(s)	Status as of 31 March 85
MINERAL TECHNOLOGY			
Computer applications in underground mine design	Queen's University	J. Pathak	In progress
Identification et mesure de la concentration de fibres d'amiante chrysolite par des techniques photoacoustiques et LASV	École Polytechnic	G. Knight	Complete
Novel mining methods for continuous mining machines in hard rock formations	Queen's University	R.J.R. Welwood	Complete
Fragmentation control through blasting	Queen's University	G. Larocque	In progress
ENERGY TECHNOLOGY			
Contrôle en temps riel des camions d'une mine en maximesantle tonnage et en assurant l'uniformité de la teneur	Montreal University	V. Srajer R.J.R. Welwood	Complete
Calibration and upgrading of the layered mechanistic slurry pipeline model using new experimental data for western Canadian coals	Queen's University	L. Geller	Complete
Natural and induced seismicity in Saskatchewan	Saskatchewan University	G. Herget	In progress
Computerized mine ventilation network simulator for Lanigan potash mine, Saskatchewan	Alberta University	M. Gangal	Complete

APPENDIX C

REPRESENTATION ON TECHNICAL COMMITTEES

INTERNATIONAL

Canadian Subcommittee of the International Electrotechnical Commission, Technical Committee 31

Electrical Apparatus for Explosive Atmospheres (chairman) ..... J.A. Bossert

International Electrotechnical Commission Subcommittee 31A

Flameproof Enclosures (chairman) ..... J.A. Bossert

International Mine Ventilation Congress

(Canadian member) ..... G. Knight

International Society for Rock Mechanics (ISRM)

Commission on Case Histories ..... D. Hedley

Commission on Fracture Toughness Testing of Rock ..... G. Swan

Committee on 1987 ISRM Congress, Montreal (General Chairman) ..... G. Herget

International Standards Organization Canadian Advisory Committee

Committee on Certification - CERTICO (member) ..... J.A. Bossert

Technical Committee 41/Subcommittee 3, Conveyor Belting (member) ..... K.J. Mintz

Technical Committee 146 - Air Quality and Working Groups, SiO_2 and Inorganic Fibres (member) ..... G. Knight

International Tunnelling Association

Tunnelling Association of Canada (member) ..... L. Geller

Organization for Economic Co-operation and Development (OECD)

International Group of Experts on Unstable Substances (IGUS) (national representative) ..... R.R. Vandebeek

IGUS - Ammonium Nitrate Working Group (co-leader) ..... R.R. Vandebeek

NEA International Intercalibration and Intercomparison Program for Radon, Thoron and their Daughters (member) ..... J. Bigu

United Nations

Group of Experts on Explosives (delegate) ..... R.R. Vandebeek

UNITED STATES OF AMERICA

Instrument Society of America

Committee SP 12 Instruments for Use in Hazardous Locations (member) ..... J.A. Bossert

Collaborative Planning Committee for Diesel Emission Reduction R & D

(CANMET representative)' ..... E.D. Dainty

American Conference of Government Industrial Hygienists

Mining Safety and Health Technical Committee (member) ..... G. Knight

CANADA - FEDERAL

Canadian Government Specifications Board (CGSB)

Diesel Fuel Panel of the CGSB Sub-Committee on Middle Distillates (member) .. J.P. Hogan

Energy, Mines and Resources Canada (EMR)

Committee on Radioactive Waste Containment (member) ..... G.E. Larocque

Occupational and Environmental Research for Uranium Production, Joint Panel
(secretary) ..... R. Tervo
(member) ..... J. Bigu

Uranium Resource Appraisal Group:
Subcommittee on Reasonably Assured Resources of Uranium (chairman) ..... Á. Füstös

Uranium Resource Appraisal Group:
Subcommittee on Estimated Additional Resources of Uranium (member) ..... Á. Füstös

Uranium Resource Appraisal Group:
Subcommittee on Economics of Supply and Demand for Uranium (member) ..... Á. Füstös

Uranium Resource Appraisal Group (member) ..... Á. Füstös

Transport Canada

Technical Committee on Dangerous Goods (member) ..... R.R. Vandebeek

CANADA - OTHER

Canadian Gas Association

Gas Fired Appliances for Hazardous Locations, No. CGA 2.25 (member) ..... G. Lobay

Canadian Geotechnical Society

Ottawa Geotechnical Group (executive member) ..... M. Bétournay

Subcommittee on Tunnelling (member) ..... M. Gyenge

Canadian Institute of Mining and Metallurgy (CIM)

Ad-Hoc Committee on Mining and Mineral Processing Research (member) ..... J.E. Udd

Algoma Branch (Laboratory representative) ..... B. Arjang

Committee on Education for the Mineral Industry (member) ..... J.E. Udd

Rock Mechanics and Strata Control Committee (vice chairman) ..... J.E. Udd

Subcommittee on Backfill (member) ..... G. Swan

Canadian Rock Mechanics Association - RMSCC

Subcommittee on Non-Explosive Breakage Methods (member) ..... M. Gyenge

Subcommittee on Monitoring (member) ..... G. Herget

Subcommittee on Soft Rock (member) ..... G. Herget

Canada EEC

Working Group on Asbestos Measurement ..... G. Knight

Canadian Standards Association

Standards Steering Committee on Electrical and Mechanical Mines Safety (vice-chairman protem) ..... J.A. Bossert

Technical Committee for "Trackless Underground Diesel Powered Mobile Equipment" (chairman) ..... E.D. Dainty

Technical Committee on Acoustics and Noise Control (Construction & Mining Machines - Task Force on Occupational Noise) (member) ..... M. Savich

Technical Committee on Fire Resistant Conveyor Belting, No. M4.22 (member) .. K.J. Mintz

Technical Committee on Fire Resistant Hydraulic Fluids, No. M4.23 (member) .. K.J. Mintz

Canadian Standards Association
Canadian Electrical Code, Part I

Steering Committee (member) ..... J.A. Bossert

Subcommittee on Sections 18, 20 and 24 (member) ..... J.A. Bossert

Canadian Electrical Code, Part II

Subcommittee on CSA Standard C22.2, No. 30:
Explosion Proof Enclosures for Use in Class I, Groups, A, B, C and D Hazardous Locations (member) ..... J.A. Bossert

Subcommittee on CSA Standard C22.2, No. 137:
Luminars for Hazardous Locations (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 152:
Combustible Gas Detection Equipment (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 157:
Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations (vice-chairman) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 159:
Plugs and Receptacles for Hazardous Locations (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 174:
Cables to be Used in Hazardous Locations (member) ..... G. Lobay

Canadian Electrical Code, Part V

Committee on CSA Standard C22.5
Use of Electricity in Mines (member) ..... G. Lobay

Canadian Uranium Producers Metallurgical Committee

(members) ..... N.K. Davé
T.P. Lim

Sault College, Elliot Lake

Advisory Committee for the Ventilation Technician Option of the Mechanical Technology Course (members) ..... S. Hardcastle
R. Tervo

APPENDIX D

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF AND STAFF CHANGES

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF

NAME	DEGREES AND DIPLOMAS	OCCUPATIONAL CATEGORY
J.E. Udd	B.Eng., M.Eng., Ph.D. (McGill); P.Eng.	Director
J.E. Evans		Secretary
ADMINISTRATIVE SERVICES		
M. Hamel		Reports & Public. Clerk
C. Sabourin		Office Manager
C. Sleeth		Fin. and Admin Clerk
E.C. Tupper		Admin Officer
CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY		
J.A. Bossert	B.Sc. (Queen's)	Manager
M.I. Inglis		Secretary
M. Boyle	Dipl. (Mech. Tech.) (Algonquin)	Technologist
E.D. Dainty	B.Sc., M.Sc., (Toronto) P.Eng.	Res. Sci.
E. Dainty	Dipl. (Inst. Tech.) (Algonquin)	Technologist
J. Ebersole	Dipl. (Electr. Tech.) (Ryerson)	Technologist
M. Gangal	B.Sc. (Agra, India), M.Sc. (Rokee, India & McGill), Ph.D. (Calgary)	Res. Sci.
G. Lobay	B.Sc. (Manitoba)	Engineer
K. Mintz	B.Sc., M.Sc. (UBC); PhD. (Toronto)	Res. Sci.
P. Mogan	B.A.Sc. (Toronto), P.Eng.	Res. Sci.
M. Ralph	Dipl. (Elect. Tech.) (Algonquin)	Technologist
N. Sarin	Dipl. (Mech. & Auto Eng.) (Oxford College of Technology), B.A.Sc. (Waterloo)	Engineer
J. Vallieries	Dipl. (Mech. Tech.) (St. Micheal's)	Technologist
CANADIAN EXPLOSIVES RESEARCH LABORATORY		
R.R. Vandebeek	B.Sc., M.Sc. (Carleton)	Manager
J. Campbell		Secretary
R. Augsten	Dipl. (Agri. Tech.) (Jena, Germany)	Technologist
K.C. Cheng	B.Sc., M.Eng. (Tainan Chen-Kung, Taiwan)	Engineer
E. Contestabile	B.Sc. (Carleton)	Phys. Sci.
T. Craig	Dipl. (Biochem. Tech.) (Algonquin)	Technologist
D. Dinel	Dipl. (Analy. Chem. Tech) (CEGEP)	Technologist
K.K. Feng	B.Sc., M.Sc., Ph.D. (Iowa)	Res. Sci.

D.E.G. Jones	B.Sc., Ph.D. (Western)	Res. Sci.
P. Lee	B.Sc. (Hong Kong Baptist)	Chemist
E. Nagy	Dipl. (Electr. & Mech. Tech.) (Ryerson)	Technologist
E.T. Pike	Dipl. (Chem. Tech.) (Dawson)	Technologist
C.A. Vary	B.Sc. (Ottawa)	Tech. Officer

ELLIOT LAKE LABORATORY

R.O. Tervo	B.A.Sc. (Toronto), Ph.D. (Bradford); P.Eng.	Manager
H.C. St. Jean		Secretary

Administrative Services

E. McElrea		Office Manager
J. Nipius		Financial Clerk
A.M. Webster		Reports & Publ'ns Clerk
B. Arjang	B.Sc., M.Sc., Ph.D. (Germany)	Res. Sci.
J. Bigu	M.Sc. (Barcelona), DTC(BA++) (Slurry) Ph.D. (Queen's)	Res. Sci.
Y.M. Boucher	Dipl. (Bio Science Tech.) (St. Clair)	Technologist
K.C. Butler	B.Sc. (Laurentian)	Technologist
N. Cloutier	B.Sc., M.Sc., (Laurentian)	Technologist
N.K. Davé	B.Sc., M.Sc. (Rajastman, India), Ph.D. (Queen's)	Res. Sci.
A.J. Frattini	Dipl. (Inst. Eng. Tech.) (Ind.)	Technologist
M. Grenier	B.Sc., M.Sc. (Laurentian)	Res. Sci.
S.G. Hardcastle	B.Sc., Ph.D. (Nottingham, England)	Res. Sci.
D.G.F. Hedley	B.Sc., Ph.D. (Newcastle), P.Eng.	Res. Sci.
G. Knight	B.Sc. (Birbeck, London)	Res. Sci.
T.P. Lim	B.Sc. (Ottawa), Dipl. (Radio Chem. Tech) (Munich, West Germany)	Phys. Sci.
H.L. Poliquin		Technologist
M. Savich	Dipl. (Min. Eng.) (Ljobljan, Yugoslavia), B.Eng., M.Eng. (McGill)	Res. Sci.
J.A. Smith		Technologist
G. Swan	B.Sc., Ph.D. (London); DIC; ARSM	Res. Sci.
L. Tirrul		Technologist
W. Zawadski		Technologist

ROCK MECHANICS LABORATORY

G.E. Larocque	B.Sc. (Carleton)	Manager
J.E. Byford		Secretary
A.B. Annor	B.A.Sc. (Ottawa); P.Eng.	Phys. Sci.
M. Bétournay	B.Sc., M.Sc.A., B.Eng. (McGill); P.Eng.	Phys. Sci.
N. Billette	B.A. (Bourget), B.Sc., M.Sc., Ph.D. (École Polytechnique)	Res. Sci.
A. Boyer	B.Sc. (Montreal)	Phys. Sci.
R. Boyle	B.Sc. (Ottawa)	Comp. Sci.
R.W.D. Clarke	B.Eng. (NSTC), P.Eng.	Engineer
D. Dugmore	Dipl. (Mach.) (CNR); Mech. Draft. (Ontario)	Draftsperson
J. Folta		Draftsperson
A. Fustos	B.S.F./F.E., B.Sc. (UBC); M.Sc. (Carleton); P.Eng.	Engineer
L. Geller	Dipl. (Mech. Eng.) (Budapest), B.Sc. (Eng.) (London), M.A.Sc. (Toronto)	Phys. Sci.
B. Gorski	Dipl. (Eng.) (St. Marks)	Technologist
M. Gyenge	Dipl. (Eng.) (Budapest), P.Eng.	Res. Sci.
G. Herget	B.Sc (Goettingen, West Germany); M.Sc., Ph.D. (Munich, West Germany); P.Eng.	Res. Sci.
F. Kapeller	Dipl. (Ind. Elect.) (Austria)	Technologist
R. Jackson	B.A.Sc. (Waterloo); P.Eng.; AECL Employee	Phys. Sci.
J. Pathak	B.Eng., M.Eng. (Sager, India), Ph.D. (Freiberg, Germany)	Engineer
N.A. Toews	B.Sc. (Queen's)	Res. Sci.
S. Vongpaisal	B.Eng., M.Eng., Ph.D. (McGill); P.Eng.	Res. Sci.
D.F. Walsh	B.Sc. (Memorial)	Phys. Sci.
R.J.R. Welwood	B.Sc. (Queen's)	Phys. Sci.
A.S. Wong	B.Sc. (National Taiwan University), M.Sc. (Ottawa)	Phys. Sci.
Y.S. Yu	B.Sc., M.Eng. (McGill)	Res. Sci.

STAFF CHANGES

APPOINTMENTS AND PROMOTIONS

Permanent Staff

A. Annor - Promoted within PC group, RML, 04/01/84

N. Billette - Research Scientist - RML, 17/12/84

R. Clarke - Engineer, RML, 26/04/84

M. Grenier - Promoted to Research Scientist, ELL, 16/11/84

D. Jones - Research Scientist, CERL, 29/10/84

F. Kapeller - Promoted within EL Group, RML, 01/04/84

J.E. Udd - Director, MRL, 01/05/84

Terms

D. Cox - Explosives Technologist, CERL, 07/01/85

J. Evans - Secretary, MRL, 18/02/85

R.J.R. Welwood - Advisor, Mining Technologist & Evaluation, MRL, 13/08/84

SEPARATIONS

Permanent

S. Ho - Mine Evaluation Programmer, RML, 22/03/85

P. MacDonald - Research Scientist, ELL, 19/10/84

Terms

M.A. Armstrong - Electronic Instrument Design Technologist, CERL, 30/11/84

D. Mitchell - Secretary, CEAL, 25/01/85

APPENDIX E

CONTRACTS, MEETINGS, FIELD TRIPS, AND JOINT CONSULTATIONS

CONTACTS, MEETINGS AND FIELD TRIPS

As a research organization it is necessary to maintain external contacts with other similar bodies for technology transfer and exchange of information related to the research programs. In this connection, several lectures and briefings on the subject of rockbursts were given to graduate students, professional engineers and the Ontario Committee on Ground Control and Emergency Preparedness (Sevenson Commission). A scientist at the Elliot Lake Laboratory was the chief technical witness at the inquest on the four fatalities that occurred as a result of the rock- bursts at Falconbridge Mine.

Mining research staff held a contract de- briefing session at Saskatoon at which eight final contract progress reports associated with the START program for potash mining research were presented by contractors. Every potash mining company operating in Saskatchewan attended the session.

During 1984/85 MRL hosted visits by scientific and technical personnel from many parts of the world as well as conducting several tours of its facilities.

MRL staff were active in 17 conferences across North America and in other parts of the world at a cost of approximately $17 500. A total of 30 technical papers were presented and 20 other publications were contributed to journals as indicated in Appendix A.

The research agreements and contracts awarded to industry, private consultants, and universities continued to grow necessitating continued supervision and travel by our staff.

MRL remains in the forefront of mineral research and cooperates with others through the exchange of information and granting programs to private industry consultants and universities. Staff members carried out 403 field trips related to these activities.

MRL scientists continued to engage in external consultations through their membership in technical committees as indicated in Appendix C. Such committees include representatives for public and private sectors as well as from academic institutions.

JOINT PROVINCIAL/FEDERAL/UNIVERSITIES/INDUSTRY/INTERNATIONAL CONSULTANTS

PROVINCIAL

Ontario Hydro
Ontario Ministry of Labour
Saskatchewan Ministry of Labour
Ontario Ministry of Natural Resourses

FEDERAL

Atomic Energy
Canadian Coast Guard
Labour Canada
National Defence

UNIVERSITIES

Laurentian University
Laval University
McGill University
McMaster University
Queen's University
Sherbrooke University
University of Alberta
University of British Columbia
University of Ottawa
University of Quebec
University of Saskatchewan
University of Toronto
Waterloo University

INDUSTRY
(*Denotes Frequent Contacts)

Alpha Nuclear Company, Mississauga, Ont.
Analygas Systems Ltd., Scarborough, Ont.
Beaver Construction Group, Dorval, Que.
Brenda Mines Ltd., Peachland, B.C.
Brunswick Mining and Smelting Corp. Ltd., Bathurst, New Brunswick
CIL Ltd., Montreal, Que.*
CIM, Montreal, Que.*
Campbell Red Lake Mines Ltd., Balmertown, Ont.*
Canadian Arsenals, Montreal, Que. *
Canadian Diamond Drilling Association, Don Mills, Ont.
Canadian Geoscience Corp., Vancouver, B.C.
Canadian Mine Development Ltd., Mississauga, Ont.
Canadian Standards Association, Toronto, Ont. *
Cape Breton Development Corp. (CBDC), Lingan Mine, Sydney, N.S. *
Central Canada Potash, Colonsay, Sask. *
Coal Mining Association Centre, Calgary, Alta.
Cominco Ltd., Kimberly, British Columbia *
Combustion Engineering Ltd., Toronto, Ont.
DSMA Atcom, Toronto, Ont.
Denison Mines Ltd., Elliot Lake, Ont. *
Denso Canada Ltd., Agincourt, Ont.
Detour Lake Mines, Timmins, Ont.
Dickenson Mines Ltd., Balmertown, Ont.
Dome Mines Ltd., South Porcupine, Ont.
Dynatec Ltd., Richmond Hill, Ont.
EDA, Toronto, Ont. *

Engine Controls Systems Ltd., Aurora, Ont.
Expro Chemicals Products Inc., Valleyfield, Que.
Falconbridge Ltd., Falconbridge, Ont. *
Golder Associates, Mississauga, Ont.
H.A. Simons Ltd., Vancouver, B.C.
HDRK Research, Sudbury, Ont. *
Hands Fireworks, Papineauville, Que. *
Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Man.
Hyundai Canada Ltd., Unionville, Ont.
INCO Metals Ltd., Sudbury, Ont. *
International Mining and Chemicals Corp. Sask.
J.S. Redpath Ltd., North Bay, Ont.
JKS/Boyles Diamond Drilling Manufacturers, Toronto, Ont.
Jarvis Clark, Burlington, Ont.
Kerr Addison Mines Ltd., Larda Lake, Ont.
Key Lake Mining Corp., Saskatoon, Sask.
Kidd Creek Mines Ltd., Timmins, Ont.
Kiena Gold Mines Ltd., Val D'Or, Que.
LEQ Measurements, Toronto, Ont.
Les Mines Selbaie, Joutel, Que. *
Levitt-Safety, Toronto, Ont.
Lornex Mining Corp. Ltd., Logan Lake, B.C.
MLH Whaling and Associates (Research) Ltd., Sudbury, Ont.
Macassa Mine, Kirkland Lake, Ont.
Mattabi Mines Ltd., Ignau, Ont.
Miltor Ltd., Sudbury, Ont.
Mines Accident Prevention Association, North Bay, Ont.
Mines Sigma (Quebec) Limitee, Val D'Or, Que.
Monenco, Montreal, Que.
Niobec, St. Nonoie, Que. *
Noranda Inc., Pointe Claire, Que. *
Oak Supply Company, Toronto, Ont.
Ontario Centre for Machinery Development, Sudbury, Ont.
Ontario Centre for Microelectronics, Ottawa, Ont.
Ontario Mining Association, Ottawa, Ont.
Ontario Research Foundation, Toronto, Ont. *
Philips Cables Ltd., Brockville, Ont.
Potash Corp., Saskatoon, Sask. *
Ramsey Engineering, Toronto, Ont. *
RE/SPEC Ltd., Calgary, Alta.
Rio Algom Ltd., Elliot Lake, Ont.
Roche Ltée., Ste-Foy, Que.
Sheritt Gordon Mines, Lyn Lake, Man.
Similkameen Mine, Pencton, B.C.
Soquem, Bagotville, Que.
Teledyne Canada, Thornbury, Ont.
Troy Manufacturing, Toronto, Ont.
Uniroyal Ltd., Bracebridge, Ont.
Vadeko International Ltd.,, Mississauga, Ont.
Vintex Inc., Brampton, Ont.
Western Resources, Campbell River, B.C.
Westar Mining Ltd., Sparwood, B.C. *
Wolf Mountain Coal, Vancouver, B.C.

INTERNATIONAL

Argone National Laboratory, U.S.A.
Armtec Controls, New Hampshire, U.S.A.
Australian Atomic Energy Commission
Batelle Laboratories, Columbus, Ohio, U.S.A.
Bharat Gold Mines, Gov't of India
Brazilian Potash Mining Company
Century Oils Ltd., London, U.K.
Chercher Explosives Research, France
Chamber of Mines, South Africa
Coal Mining Research Institute, Essen, West Germany

Conzinc Mine, Broken Hill, Australia
Corning Glass Works, New York, U.S,A.
Electric Power Research Inst. Palo Alto, California, U.S.A.
E.Z. Co. Ltd., Australia
Eickhoff Corp., Pittsburgh, U.S.A.
General Monitors Corp., Costa Mesa, California
IEC Central Office, Geneva
J.H. Fenner & Co. Ltd., Marfleet, Hull, U.K.
Korean Trade Missions
Michigan Technical University, Lasing, MI, U.S.A.
Mines de Potasse D'Alsace
MSHA, Triadelphia, W. Virginia, U.S.A.
Oklahoma University, Oklahoma, U.S.A.
Penn State University, Pack, PA, U.S.A.
Peoples Republic of China
Petro Mesa
Rand Mines, South Africa
Reliance Electric Ltd., Cleveland, Ohio, U.S.A.
Scandura, U.S.A.
Selco, London, U.K.
Tara Mines Ltd, Knockumber, Ireland
Tokyo Gas Co., Tokyo
U.S. Bureau of Mines, Pittsburgh, U.S.A.
U.S. Mine Safety Health Administration
Wajax Ltd., U.K.
Westfalia, Lunen, West Germany